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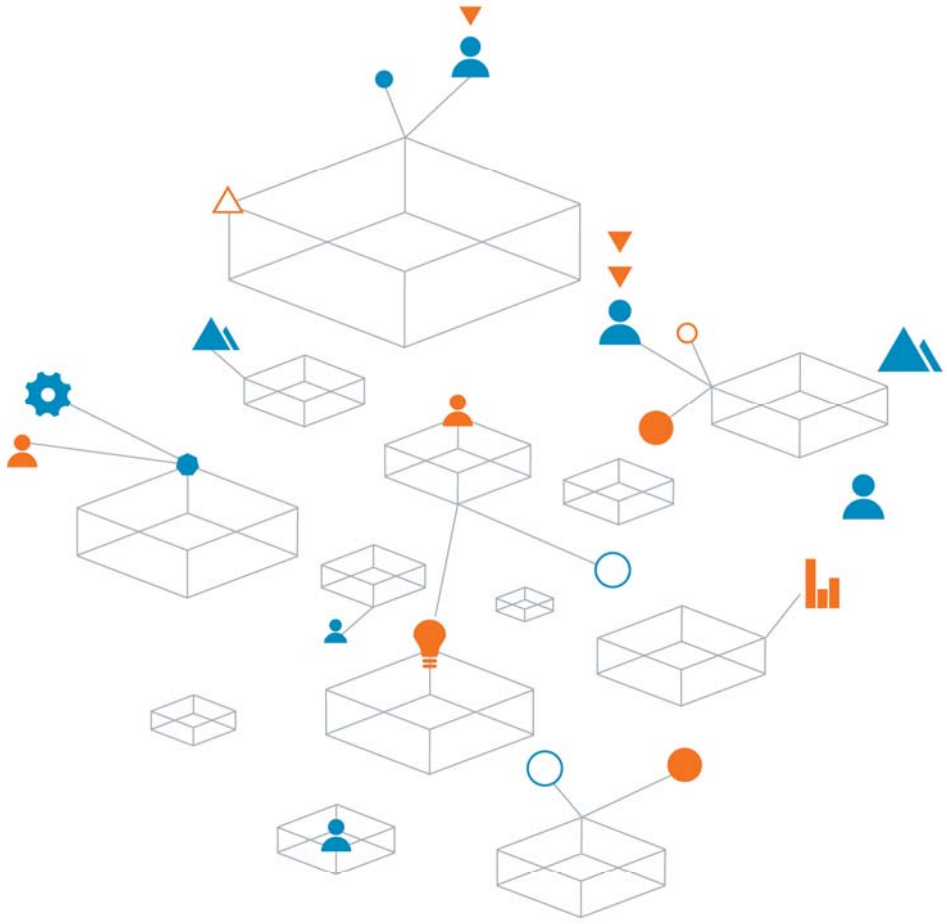
MORRISON HERSHFIELD

Preliminary Foundation Investigation and Design Report

Highway 400 Retaining Walls and Embankment Widening, from south of BCR to North of Tiffin Street, City of Barrie, G.W.P. 2074-11-00, Design-Build Ready Package

GEOTETOB22161AA - DRAFT

15 December, 2014



Trust is the cornerstone of all our projects

20 Meteor Drive
Toronto, Ontario
M9W 1A4 Canada
t: 416 213 1255
f: 416 213 1260
coffey.com

Morrison Hershfield

Suite 600, 235 Yorkland Blvd, Toronto, ON, M2J 1T1

T 416 499 3110

www.morrisonhershfield.com

15 December, 2014

Attention: **Bruce Dickey**, P.Eng., AVS

Dear Sir

RE: Draft – Preliminary Foundation Investigation and Design Reports, Highway 400 Retaining Walls and Embankment Widening, from south of BCR to North of Tiffin Street, City of Barrie, G.W.P. 2074-11-00, Design-Build Ready Package

Coffey is pleased to present the Foundation Investigation and Design Reports (for a Design-Build Ready Package) relating to the above noted project.

Please call us on 416 213 5357 should you require further clarification on any aspects of the reports.

For and on behalf of Coffey.

Draft

Sanket Shah, P.Eng.
Project Manager, Geotechnical Engineer

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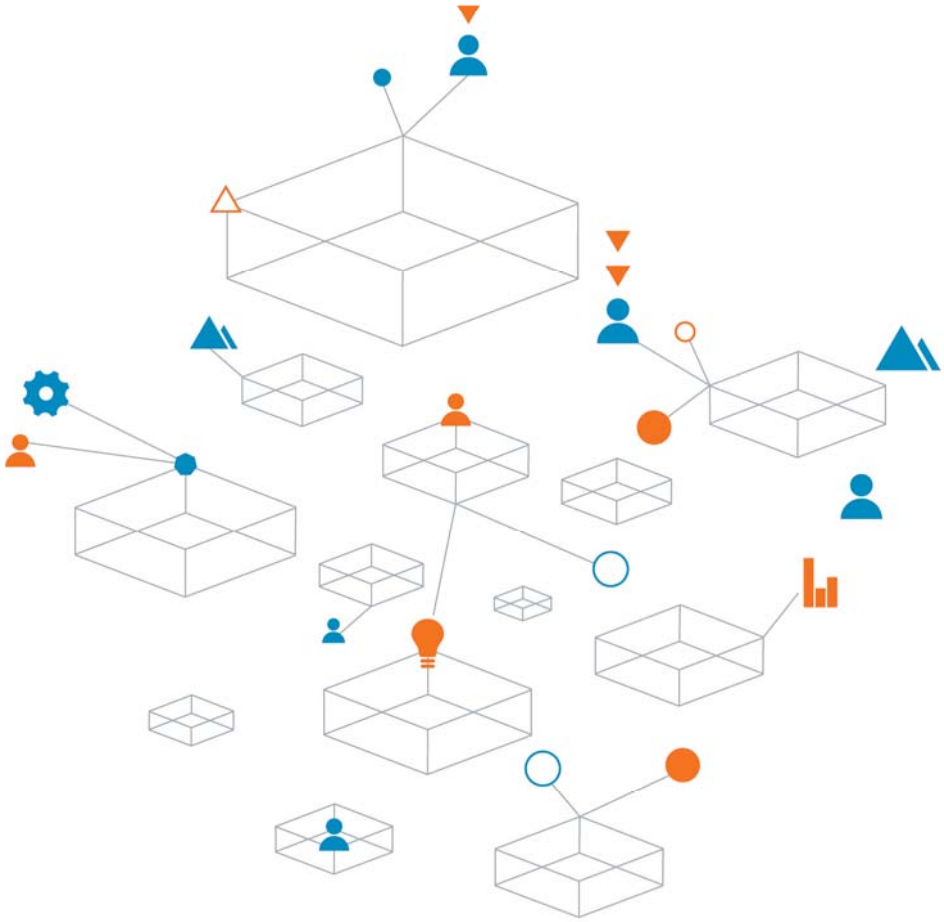
MORRISON HERSHFIELD

Preliminary Foundation Investigation Report

Highway 400 Retaining Walls and Embankment Widening, from south of BCR to North of Tiffin Street, City of Barrie, G.W.P. 2074-11-00, Design-Build Ready Package

GEOTETOB22161AA - DRAFT

15 December, 2014



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DRAFT
PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 400 RETAINING WALLS AND EMBANKMENT WIDENING
FROM SOUTH OF BCR TO NORTH OF TIFFIN STREET, CITY OF BARRIE
G.W.P. 2074-11-00, DESIGN-BUILD READY PACKAGE

1 Introduction

Coffey was retained by Morrison Hershfield (MH) on behalf of the Ministry of Transportation Ontario (MTO) to provide preliminary foundation investigation and engineering services for the proposed design-build (DB) ready package for MTO G.W.P. 2074-11-00, *Highway 400/Tiffin Street Overpass Structure Replacements and Highway 400/Barrie-Collingwood Railway (BCR) Overhead Structure Rehabilitation and Addition*. The project extends from just north of the existing Essa Road – Highway 400 Interchange to just south of the Dunlop Street – Highway 400 Interchange. This investigation report is prepared for proposed permanent retaining walls, temporary retaining walls, and embankment widening within the project limits.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes, and to assess the engineering characteristics of the subsurface soils by means of field and laboratory tests. The findings of the investigation are presented in this report. It provides factual information on subsurface soil and groundwater conditions, in-situ testing, and laboratory test results. Owing to known TCE (trichloroethylene) contamination in the project area and the design-build nature of the project, the subsurface investigation scope was limited to a reduced number of boreholes and a requirement not to investigate the subsurface conditions below certain pre-specified depths/elevations.

2 Site Description and Physiography

2.1 Site and Structure Description

The overall project is located in the City of Barrie (Townships of Innisfil and Vespra). Based on the sectional drawings provided by MH, the existing ground elevation beyond the highway embankment footprint is 231-234 m. The existing maximum embankment height within the project limits is about 6.5 m, with 2:1 side slopes. The areas on the east and west sides of Highway 400 have been developed and include both residential and mixed commercial and industrial land uses.

Photographs of the site are presented in **Appendix C**.

2.2 Physiography

The project site is located in the Simcoe Lowlands Physiographic Region of Southern Ontario. The soil deposits are either deltaic or lacustrine in origin. They consist of fine grained non-cohesive silts and fine sands intermixed with thin (< 1 m thickness) stringers of clayey silt deposited during quieter periods of sedimentation.

Due to the depositional environment and lack of adequate drainage that encouraged in situ decay of growing vegetation, peat and muck lenses and layers are present in depressed areas in the upper horizons of deltaic and lacustrine silt and sand deposits.

3 Investigation

3.1 Field Work

The borehole locations and depths were discussed with MH to maximize borehole coverage to develop an effective design-build ready package. Due to the existing trichloroethylene (TCE) contamination within the project limit, borehole depths/elevations were determined by MH environmental specialists to minimize possible environmental issues.

Total fourteen (14) boreholes were advanced for the proposed retaining walls and embankment widening. Boreholes RW1 to RW5 were advanced along the existing highway ROW for a proposed permanent retaining wall. Nine (9) boreholes were drilled from the existing highway grade with traffic control (during nightly lane closures as directed by MTO COMPASS) for proposed temporary retaining walls. Boreholes RW6 to RW 9 were drilled along the existing highway north bound (NB) edge of pavement and Boreholes RW9 to RW14 were put down along existing highway centreline.

The borehole locations were laid out by Coffey personnel on the basis of chainage painted by MH along Highway 400. Underground services were cleared using Ontario One Call and private locators. The field work was conducted from October 2nd to 22nd, 2014 under Coffey supervision.

The boreholes were drilled with truck mounted CME-75 machines (owned and operated by Davis Drilling of Milton, Ontario) equipped with solid stem and hollow stem augers. Soil samples were obtained in the Standard Penetration Test (SPT, ASTM D-1586), with N values noted in blows/0.3m. All samples were placed in moisture proof bags after field classification. They were subsequently re-examined under controlled laboratory conditions prior to assigning laboratory tests. The borehole locations were tied in to NAD83 coordinates and the geodetic elevations at the borehole locations were determined by MH surveyors.

Table 3.1 provides a summary of the field work.

Table 3.1 – Summary of Boreholes

Structure	BH No.	Borehole Locations (Station and Offset from the centerline)	Ground Elevation (m)	Borehole Depth (m)	Borehole Bottom Elevation (m)	Piezometer/ Monitoring Well
Permanent Retaining Walls, East ROW	RW1	29+358, 40 m Rt	233.3	5.2	228.1	
	RW2	29+474, 42 m Rt	234.0	5.9	228.1	Piezometer
	RW3	29+632, 42 m Rt	234.5	5.8	228.7	Piezometer
	RW4	10+060, 42 m Rt	233.2	8.2	225.0	Piezometer
	RW5	10+200, 42 m Rt	234.1	5.8	228.3	
Temporary Retaining Walls	RW6	29+630, 12 m Rt	242.3	14.3	228.0	
	RW7	10+060, 12 m Rt	238.8	11.3	227.5	
	RW8	10+200, 16 m Rt	237.1	9.8	227.4	
	RW9	10+326, 16 m Rt	236.1	8.2	227.9	
	RW10	29+574, 3 m Lt	242.9	15.1	227.8	
	RW11	29+696, 3 m Lt	241.0	14.3	226.7	
	RW12	10+120, 4 m Lt	237.7	9.8	228.0	
	RW13	10+268, 5 m Lt	236.7	8.2	228.5	
	RW14	10+388, 5 m Lt	235.8	8.2	227.6	

Three piezometers were installed in Borehole RW2, RW3 and RW4 for long term groundwater monitoring. Remaining boreholes were backfilled and sealed in accordance with MOE Reg. 903.

3.2 Laboratory Testing

The following tests were performed on selected soil samples:

- Natural moisture content;
- Grain size analyses (sieve and hydrometer). and
- Atterberg limits

Laboratory test results are presented in **Appendix B**. The results of laboratory tests are also presented on the Record of Borehole Sheets in **Appendix A**.

4 Subsurface Conditions

The native soil below and adjacent to the Highway 400 embankment fill is stratified silty sand to sandy silt, sand, silt and sand & silt.

Detailed descriptions of the materials encountered in the boreholes are presented on the Record of Borehole Sheets presented in **Appendix A**, which includes Explanation of Terms Used in the Report.

Borehole location plan and the generalized subsurface condition are presented on **Drawings 1, 2 and 3**. Soil and groundwater conditions are described in the following sections.

4.1 Topsoil

The topsoil thickness was 100-200 mm along the east ROW.

4.2 Pavement Structure

The pavement asphaltic concrete thickness was on average 300 mm (range: 200 mm to 400 mm) underlain by sand and gravel base and subbase course of 0.5 m thickness Average N values of 41 blows/0.3 m (from 16 to 87 blows/0.3 m) suggest the existing fill is compact to very dense beneath the RW numbered hole locations.

4.3 Embankment Fill

Below the topsoil, about 1.5 m thick silty sand fill (possibly placed for grading purpose) was contacted in Boreholes RW1 to RW5 drilled in the east embankment toe area. Based on N values ranging from 3 to 10 blows/0.3 m, this fill is typically in a loose condition.

Under the pavement structure in the remaining boreholes (BH RW6 to RW14), embankment fill consisted of silty sand, trace gravel and clay, extending to elev. 235 to 233 m.

Gradation testing of seven samples (see **Figure B-1**) gave the following results:

Gravel:	1-5%
Sand:	60-82%

Silt and Clay: 15-39% (9-12% clay sized particles)

In the embankment fill, N values ranged from 7 to 43 blows/0.3 m, indicating a loose to dense condition (typically compact).

The Natural moisture content of the embankment fill was 5-17% (average 9%).

Cobbles, boulders and rock fill were not encountered in boreholes drilled through the fill, but their likely presence elsewhere within the Highway 400 embankment fill should not be discounted.

4.4 Sandy Silt to Silty Sand, Silt, Sand and Sand & Silt

The native soils beneath and adjacent to the Highway 400 embankment are sandy silt to silty sand, silt, sand and sand & silt. This stratified deposit contains trace gravel and clay. All boreholes were terminated within this deposit at depths ranging from 4.5 m to 15.1 m below the existing grade (elev. 231.3 to 225.0 m).

Gradation tests on eleven samples (see **Figure B-2**) show the following grain-size distribution:

Gravel: 0-5%

Sand: 0-93%

Silt: 6-92%

Clay sized particles: 4-10%

One Atterberg limits test was attempted on a sample from Borehole RW4. It was non-plastic.

The natural moisture content of the stratified natural soil had a range of 3% to 26% (average 6%).

N values ranging from 2 to 50 blows/0.3 m indicate a very loose to dense condition (generally compact based on an average N value of 13 blows/0.3 m in the embankment toe area and an average N value of 23 blows/0.3 m under the highway).

4.5 Groundwater Conditions

Groundwater levels were observed in the open boreholes while drilling and upon completion of each borehole.. The groundwater levels observed during and after the investigation are summarized in Table 4.5.1 and are also presented on the Record of Borehole Sheets in **Appendix A**.

Table 4.5.1. Groundwater Observations

Piezometer or Monitoring Well	Ground Elevation (m)	Date	Depth to Water Level (m)	Groundwater Elevation (m)
RW1	233.3	Upon completion	2.1*	231.2
RW2	234.0	October 31, 2014 (about 3.5 weeks after installation)	2.4	231.6
RW3	234.5	October 31, 2014 (about 4 weeks after installation)	4.3	230.2
RW4	233.2	October 31, 2014 (about 4 weeks after installation)	3.6	299.6
RW5	234.1	Upon completion	3.7*	230.4
RW6	242.3	Upon completion	12.2*	230.1
RW7	238.8	Upon completion	8.8	230.0
RW8	237.1	Upon completion	5.2	231.9

Piezometer or Monitoring Well	Ground Elevation (m)	Date	Depth to Water Level (m)	Groundwater Elevation (m)
RW9	236.1	Upon completion	4.6	231.5
RW10	242.9	Upon completion	11.6	231.3
RW11	241.0	Upon completion	10.7	230.3
RW12	237.7	Upon completion	6.7	231.0
RW13	236.7	Upon completion	5.5*	231.2
RW14	235.8	Upon completion	6.1*	229.7

*cave-in depth

Based on above measurements, the groundwater table at the site is between elev. 232 m and 230 m.

It should be noted that groundwater levels are subject to variation due to the influence of rainfall, seasons and water level in the water courses.

For and on behalf of Coffey.

Draft

Gwangha Roh, P.Eng., Ph.D.
Associate Geotechnical Engineer

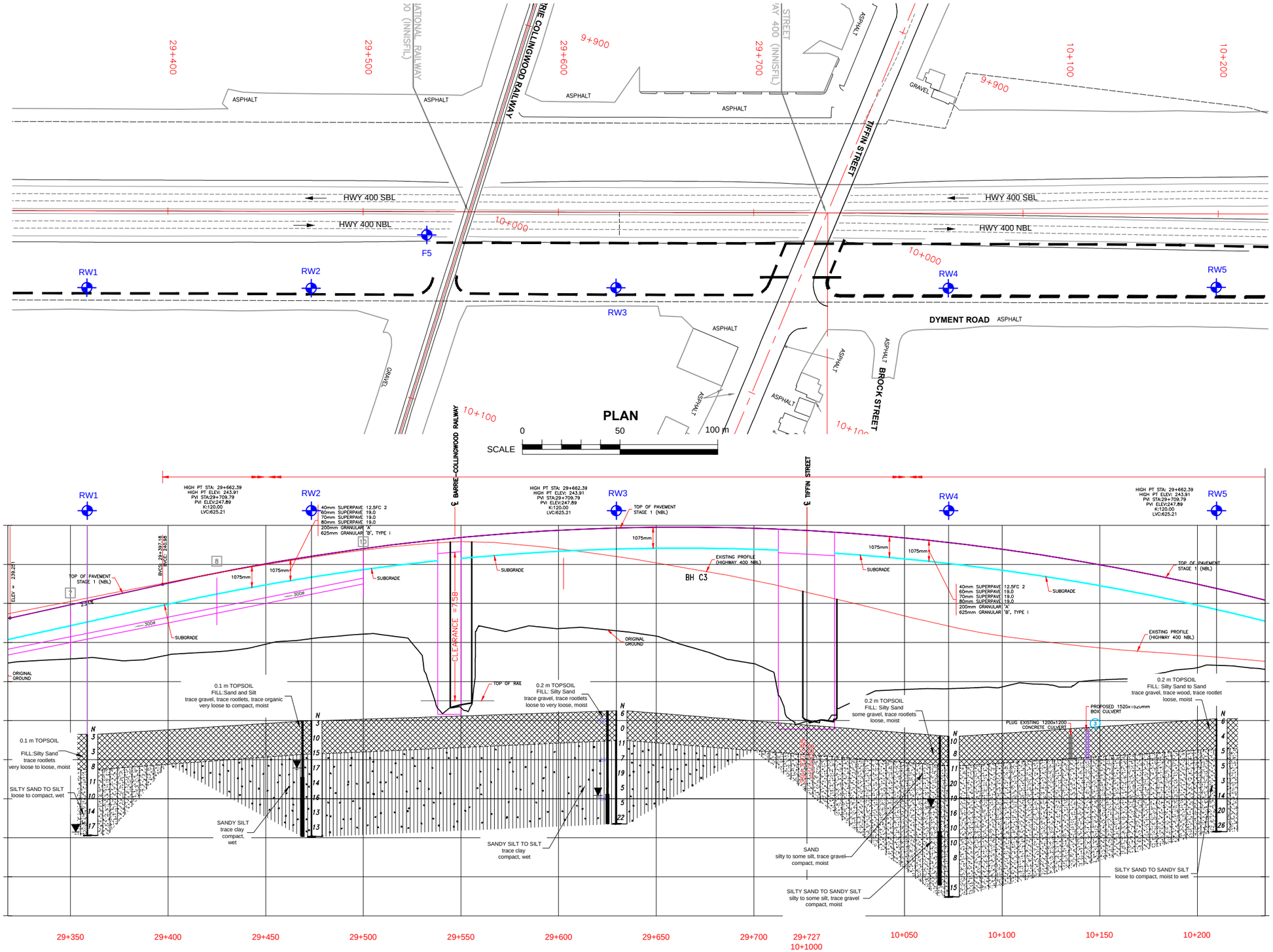
Draft

Sanket Shah, P.Eng.
Project Manager, Geotechnical Engineer

Draft

Cam Mirza, P.Eng.
MTO Designated Contact, Principal

Drawings



DISTRICT
CONT. No.
WP No. -

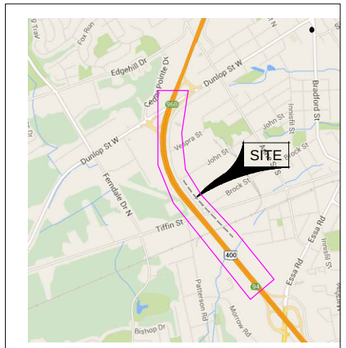
Highway 400 Permanent Retaining Wall NBL

Borehole Location Plan and Soil Strata

SHEET

METRIC

coffey



KEY PLAN
N.T.S.

LEGEND

- Borehole
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
RW1	233.3	288534.4	4914286.9
RW2	234.0	288460.9	4914375.2
RW3	234.5	288360.6	4914494.8
RW4	233.2	288251.6	4914625.5
RW5	234.1	288163.2	4914730.5

-NOTE-

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

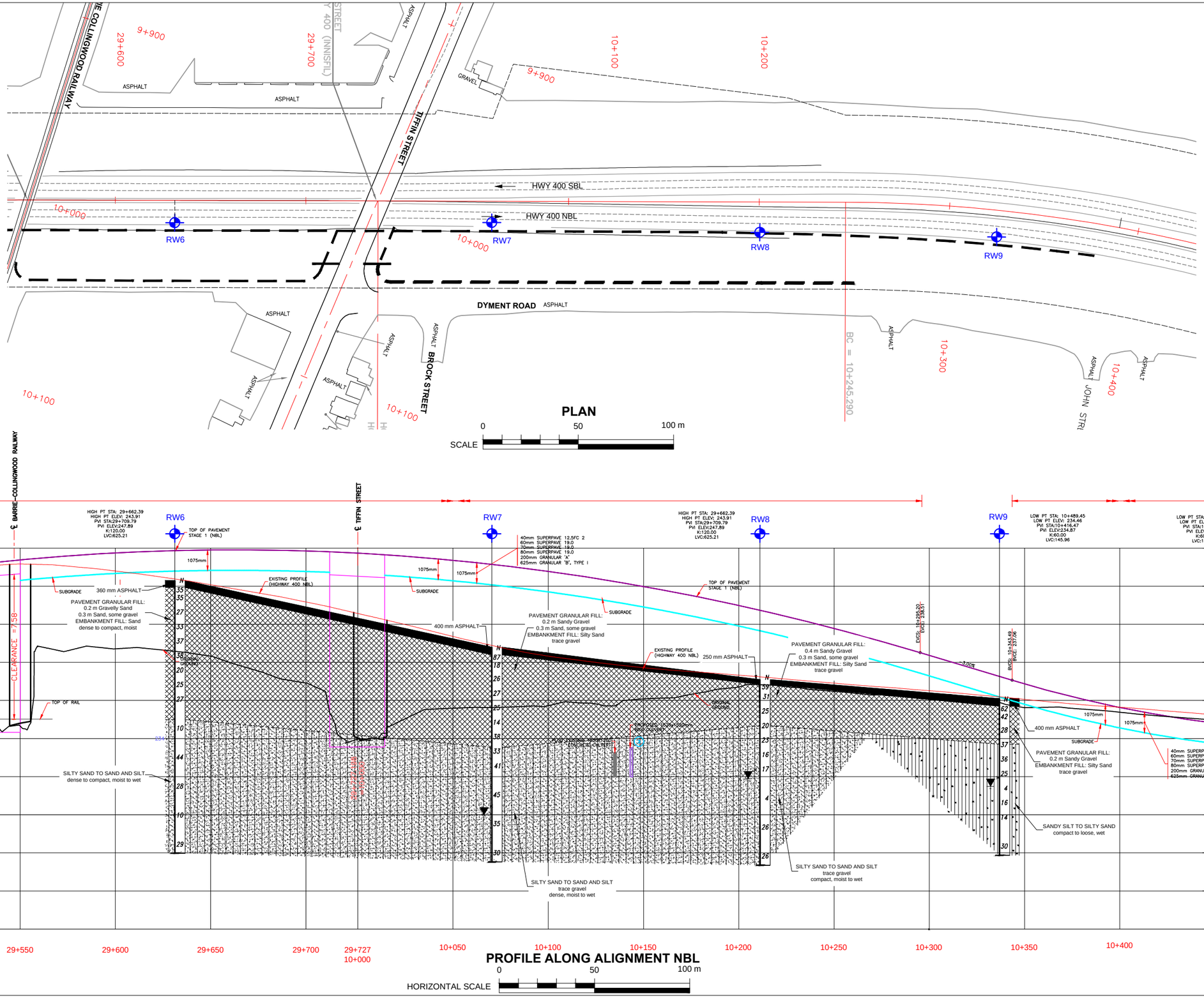
NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. - | PROJECT No. GEOTETOB22161AA

REVISIONS

DESCRIPTION

DESIGN GR	CHK SH	CODE	LOAD	DATE Dec /14	
DESIGN SSH	CHK CM	SITE -	STRUCT	DWG	DWG 1



DISTRICT
CONT. No.
WP No. -

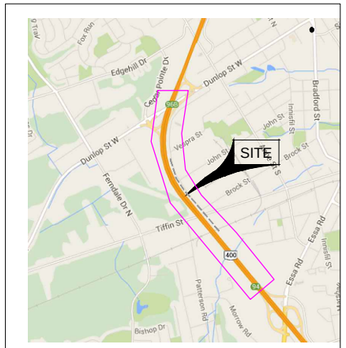
Highway 400 Temporary Retaining Wall NBL

Borehole Location Plan and Soil Strata

SHEET

coffey

METRIC



KEY PLAN
N.T.S.

LEGEND

- Borehole
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
RW6	242.3	288338.8	4914478.8
RW7	238.8	288232.0	4914606.4
RW8	237.1	288145.7	4914717.6
RW9	236.1	288067.8	4914814.5

-NOTE-

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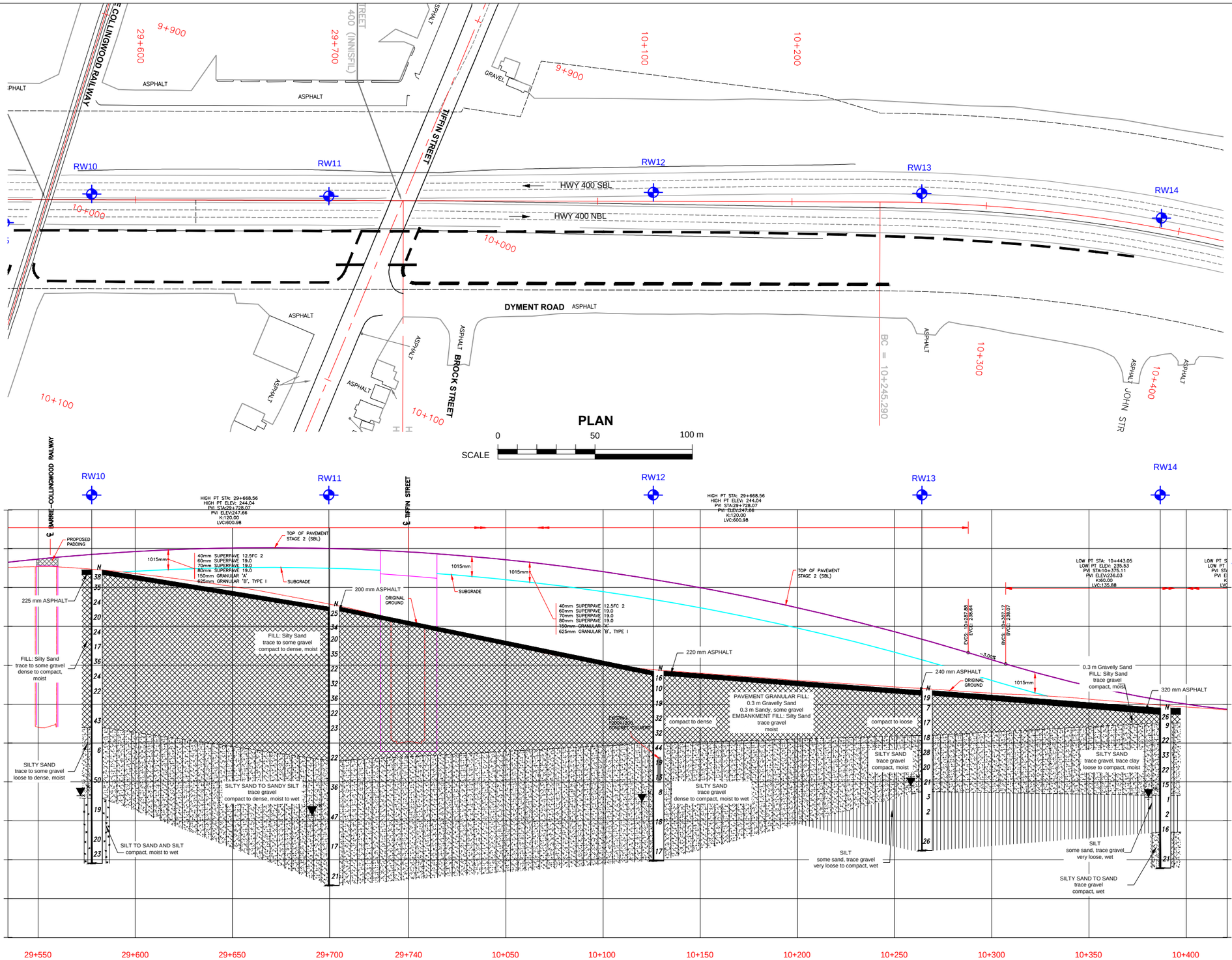
GEOCRES No. - | PROJECT No. GEOTETOB22161AA

REVISIONS

			DESCRIPTION

DESIGN	GR	CHK	SH	CODE	LOAD	DATE	Dec /14
DESIGN	SSH	CHK	CM	SITE -	STRUCT	DWG	DWG 2



DISTRICT
CONT. No.
WP No. -

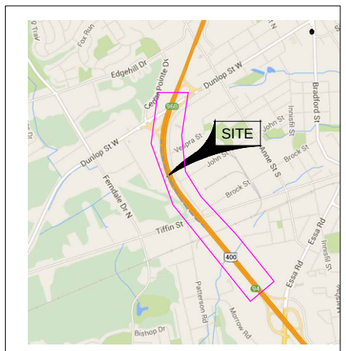
Highway 400 Temporary Retaining Wall SBL

Borehole Location Plan and Soil Strata

SHEET

METRIC

coffey



KEY PLAN
N.T.S.

LEGEND

- Borehole
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
RW11	241.0	288284.4	4914522.5
RW12	237.7	288175.8	4914649.3
RW13	236.7	288087.6	4914755.6
RW14	235.8	288018.2	4914858.3

-NOTE-

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. - | PROJECT No. GEOTETOB22161AA

REVISIONS

			DESCRIPTION

DESIGN	GR	CHK	SH	CODE		LOAD	DATE Dec /14
DESIGN	SSH	CHK	CM	SITE -	STRUCT	DWG	DWG 3

Appendix A

Explanation of Terms Used in Report and Record of Borehole Sheets

EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINT AND BEDDING:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
σ_1, σ_2, σ_3	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
ε_1, ε_2, ε_3	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max}-e}{e_{max}-e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $(W_L - W_L)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_P)/I_P$	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(W_L - W) / 1_P$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERED SOIL	e_{max}	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW1 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 29+359, 39.3 m Rt C/L (N 4914286.9, E 288534.4) ORIGINATED BY JD

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 06/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
233.3	GROUND SURFACE										
0.0	0.1 m **TOPSOIL**		1	SS	3		233				
	FILL: Silty Sand trace rootlets brown, very loose to loose, moist		2	SS	3		232				
231.5											
1.8	**SILTY SAND TO SILT** brown to grey, loose to compact wet		3	SS	8		231				0 43 53 4 wet spoon
			4	SS	11						
			5	SS	10		230				
	silt trace clay		6	SS	14		229				0 2 88 10
228.1			7	SS	17	▼					
5.2	End of Borehole Water level @ 5.0 m (not stabilized)* upon completion before cave-in cave-in @ 2.1 m upon completion.										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

+ ³, × ³: Numbers refer to Sensitivity

15-20-10-5 (%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW2

1 OF 1

METRIC

GWP 2074-11-00 LOCATION 29+474, 39.3 m Rt C/L (N 4914375.2, E 288460.9) ORIGINATED BY JD

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 06/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.0	GROUND SURFACE						234				
0.0	0.1 m **TOPSOIL** **FILL:** Sand and Silt trace gravel, trace rootlets, trace organic dark grey, very loose tocompact, moist		1	SS	3						
			2	SS	10		233				
232.3											
1.7	**SANDY SILT** trace clay brown, compact, wet		3	SS	15						0 40 55 5
			4	SS	17		232				
			5	SS	14		231				
			6	SS	16		230				wet spoon
	silty clay		7	SS	13		229				
228.1			8	SS	13						
5.9	End of Borehole Piezometer installed to 5.9 m. Piezometer water level records : Oct. 31, 2014 2.4 m										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 20 40 60 80 100

WATER CONTENT (%): 10 20 30

$+^3$, $\times^3$: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW3

1 OF 1

METRIC

GWP 2074-11-00 LOCATION 29+630, 38.7 Rt C/L (N 4914494.8, E 288360.6) ORIGINATED BY LG

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.5	GROUND SURFACE										
0.0	0.2 m **TOPSOIL**		1	SS	6		234		○		
	FILL: Silty Sand trace gravel, trace rootlet dark grey, loose to very loose, moist		2	SS	0				○		
233.0							233				
1.5	**SANDY SILT TO SILT** trace of clay brown, compact, moist		3	SS	11				○		
	loose		4	SS	7		232		○		0 19 72 9 wet spoon
			5	SS	19				○		
			6	SS	5		231		○		0 0 92 8
	silt trace clay loose		7	SS	5		230		○		
228.7			8	SS	22		229		○		
5.8	End of Borehole Piezometer installed to 5.8 m. Piezometer water level records : Oct. 02, 2014 4.0 m Oct. 31, 2014 4.3 m										

+ ^{3}, × ^{3} : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH RW4

1 OF 1

METRIC

GWP 2074-11-00 LOCATION 10+062, 38.5 m Rt C/L (N 4914625.5, E 288251.6) ORIGINATED BY JD

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 06/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
233.2	GROUND SURFACE										
0.0	0.1 m **TOPSOIL** **FILL:** Silty Sand some gravel, trace rootlet brown, loose, moist		1	SS	10		233				
			2	SS	8		232				
231.7											
1.5	**SAND** silty to some silt, trace gravel brown, compact, moist		3	SS	11		231				
			4	SS	20						1 93 (6)
230.0											
3.2	**SILTY SAND TO SANDY SILT** brown to grey, compact, wet		5	SS	19	▼	230				
			6	SS	16		229				0 3 88 9 wet spoon
	silt, trace clay		7	SS	10		228				
			8	SS	10						
			9	SS	8		227				
	loose										
			10	SS	15		226				
225.0							225				
8.2	End of Borehole Piezometer installed to 8.2 m. Piezometer water level records : Oct. 06, 2014 4.0 m Oct. 31, 2014 3.6 m										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW5 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 10+199, 37.6 m Rt C/L (N 4914730.5, E288163.2) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Solid Stem Auger COMPILED BY MP

DATUM Geodetic DATE 02/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
234.1	GROUND SURFACE										
0.0	0.2 m **TOPSOIL**										
	FILL: Silty Sand to Sand trace gravel, trace wood, trace rootlet dark brown, loose, moist		1	SS	6		234				
			2	SS	4		233				
232.6											
1.5	**SILTY SAND TO SANDY SILT** brown to grey, loose to compact, moist to wet		3	SS	5		232				0 91 (9)
			4	SS	5						wet spoon
	trace clay		5	SS	3		231				
			6	SS	14		230				
			7	SS	20		229				
228.3			8	SS	26						
5.8	End of Borehole Cave-in @ 3.7 m upon completion.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW6 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 29+631, 11.7 m Rt C/L (N 4914478.8, E 288338.8) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 22/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.3	GROUND SURFACE										
0.0 / 241.9	360 mm **ASPHALT**										
0.4	**PAVEMENT GRANULAR FILL:** 0.2 m Gravelly Sand; 0.3 m Sand, some Gravel. **EMBANKMENT FILL:** Sand, grey to brown, dense to compact, moist		1	SS	35		242		o		
			2	SS	35				o		
			3	SS	27		241		o		5 79 (16)
			4	SS	33		240		o		
	dense		5	SS	37		239		o		
			6	SS	38		238		o		
			7	SS	20				o		
			8	SS	25		237		o		
			9	SS	27		236		o		
235.0											
7.3	**SILTY SAND TO SAND AND SILT** brown to grey, dense to compact, moist to wet		10	SS	10		235		o		
			11	SS	44		234		o		
			12	SS	28		233		o		wet spoon
			13	SS	10		232		o		
			14	SS	29		231		o		
228.0							230		o		
14.3	End of Borehole Cave-in @ 12.2 m upon completion.						229		o		
							228				

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15}$ $\frac{5}{10}$ (%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW7 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 10+060, 11.2 m Rt C/L (N 4914606.4, E288232) ORIGINATED BY JD

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 21/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
238.8	GROUND SURFACE										
0.0 / 238.4	400 mm **ASPHALT**										
0.4	**PAVEMENT GRANULAR FILL:** 0.2 m Sandy Gravel **EMBANKMENT FILL:** Silty Sand trace gravel		1	SS	87		238				
			2	SS	18						
			3	SS	26		237				1 60 27 12
			4	SS	27		236				
			5	SS	25						
			6	SS	14		235				
	dense		7	SS	38		234				
233.5											
5.3	**SILTY SAND TO SAND AND SILT** trace gravel brown to grey, dense, moist to wet		8	SS	33		233				
			9	SS	41		232				
			10	SS	45		231				
						▼	230				
	gravelly sand some silt		11	SS	35		229				wet spoon
			12	SS	30		228				
227.5											
11.3	End of Borehole Water level @ 8.8 m (not stabilized)* upon completion.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW8 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 10+200, 15.9 m Rt C/L (N 4914717.6, E 288145.7) ORIGINATED BY JD

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 20/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.1	GROUND SURFACE						237				
236.9 / 0.0	250 mm **ASPHALT**										
0.3	**PAVEMENT GRANULAR FILL:** 0.4 m Sandy Gravel **EMBANKMENT FILL:** Silty Sand trace gravel		1	SS	59				○		
			2	SS	31		236		○		1 63 27 9
			3	SS	25				○		
234.7							235				
2.4	**SILTY SAND TO SAND AND SILT** trace gravel brown to grey, compact moist to wet		4	SS	20				○		
			5	SS	23		234		○		
			6	SS	16		233		○		
			7	SS	17	▼*			○		
			8	SS	7		232		○		wet spoon
	loose		9	SS	4		231		○		
			10	SS	26		230		○		
	silt, some sand		11	SS	26		229		○		
227.4							228				
9.8	End of Borehole Water level @ 5.2 m (not stabilized)* upon completion.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW9

1 OF 1

METRIC

GWP 2074-11-00 LOCATION 10+326, 13.9 Rt C/L (N 4914814.5, E 288067.8) ORIGINATED BY JD

DIST _____ HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 21/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa) / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
236.1	GROUND SURFACE									
0.0 / 235.7	400 mm **ASPHALT**						236			
0.4	**PAVEMENT GRANULAR FILL:** 0.2 m Sandy Gravel **EMBANKMENT FILL:** Silty Sand trace gravel		1	SS	62					
			2	SS	42		235			
			3	SS	28					4 62 24 10
233.7							234			
2.4	**SANDY SILT TO SILTY SAND** brown to grey, compact to loose wet		4	SS	37					
			5	SS	36		233			
			6	SS	25		232			
	very loose		7	SS	4	▼				wet spoon
	trace clay		8	SS	16		231			
			9	SS	14		230			
							229			
227.9			10	SS	30		228			
8.2	End of Borehole Water level @ 4.6 m (not stabilized)* upon completion.									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH RW10 1 OF 2 METRIC

GWP 2074-11-00 LOCATION 29+578, 3.0 m Lt C/L (N 4914428.2, E288361.8) ORIGINATED BY JD

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 14/10/2014 15/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.9	GROUND SURFACE										
242.9 / 0.0	225 mm **ASPHALT**										
242.7 / 0.2	0.4 m gravelly sand to sand some gravel		1	SS	38		242		o		
			2	SS	35				o		
			3	SS	24		241		o		
	FILL: Silty Sand trace to some gravel brown, dense to compact, moist		4	SS	20				o		
			5	SS	24		240		o		3 82 (15)
			6	SS	17		239		o		
			7	SS	36		238		o		
			8	SS	24				o		
			9	SS	22		237		o		
							236				
234.8 / 8.1			10	SS	43		235		o		
	SILTY SAND trace to some gravel brown, loose to dense, moist						234				
			11	SS	6				o		
							233				
			12	SS	50		232		o		
231.2 / 11.7						▼					
	SILT TO SAND AND SILT brown to grey, compact, moist to wet		13	SS	19		231		o		1 16 75 8 wet spoon
							230				
			14	SS	20		229		o		
			15	SS	23		228		o		

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH RW10 2 OF 2 METRIC

GWP 2074-11-00 LOCATION 29+578, 3.0 m Lt C/L (N 4914428.2, E288361.8) ORIGINATED BY JD

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 14/10/2014 15/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
227.9											
227.8											
15.1	End of Borehole Water level @ 11.6 m (not stabilized)* upon completion.										

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW11 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 29+700, 2.2 m Lt C/L (N 4914522.5, E 288284.4) ORIGINATED BY JD

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 14/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
241.0	GROUND SURFACE						241				
240.8	200 mm **ASPHALT**										
0.2	0.4 m gravelly sand		1	SS	25				○		
	FILL: Silty Sand trace to some gravel brown, compact to dense, moist		2	SS	34		240		○		
			3	SS	20		239		○		
	sandy gravel		4	SS	35				○		4 78 (18)
	sand		5	SS	22		238		○		
			6	SS	32		237		○		
			7	SS	36		236		○		
			8	SS	22		235		○		
			9	SS	23		234		○		
233.1											
7.9	**SILTY SAND TO SANDY SILT** trace gravel brown to grey, compact to dense moist to wet		10	SS	22		233		○		
	silty sand		11	SS	36		232		○		
	sandy silt		12	SS	47	▼*	231		○		wet spoon
			13	SS	17		230		○		
			14	SS	21		229		○		
226.7							228		○		
14.3	End of Borehole Water level @ 10.7 m (not stabilized)* upon completion.						227		○		

$+^3$, $\times^3$: Numbers refer to Sensitivity

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW12 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 10+129, 4.5 m Lt C/L (N 4914649.3, E 288175.8) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 14/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
237.7	GROUND SURFACE										
237.6	220 mm **ASPHALT**										
0.2	**PAVEMENT GRANULAR FILL:** 0.3 m Gravelly Sand; 0.3 m Sandy, some gravel **EMBANKMENT FILL:** Silty Sand, trace gravel, brown, compact to dense, moist		1	SS	16		237		o		
			2	SS	10				o		
			3	SS	19		236		o		3 70 (27)
			4	SS	32		235		o		
234.0			5	SS	32				o		
3.7	**SILTY SAND** trace gravel, brown to grey, dense to compact, moist to wet		6	SS	44		234		o		
			7	SS	19		233		o		
			8	SS	13		232		o		
	loose silty clay lenses		9	SS	8	▼[x]	231		o		
			11	SS	18		230		o		wet spoon
							229				
228.0			12	SS	17		228		o		
9.8	End of Borehole Water level @ 6.7 m (not stabilized)* upon completion.										

+ [3], × [3]: Numbers refer to Sensitivity

15-20-5-10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH RW13 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 10+267, 4.8 Lt C/L (N 4914755.6, E288087.6) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 14/10/2014 CHECKED BY SH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
236.7 0.0	GROUND SURFACE										
236.5 0.2	240 mm **ASPHALT**										
	PAVEMENT GRANULAR FILL: 0.3 m Gravelly Sand; 0.3 m Sandy, some gravel **EMBANKMENT FILL:** Silty Sand, trace gravel, brown, compact to loose, moist		1	SS	19		236				
			2	SS	7						
			3	SS	17		235				
234.4 2.3											
	SILTY SAND, trace gravel, brown, compact, moist		4	SS	18		234				
			5	SS	28						
			6	SS	20		233				
			7	SS	21	▼*	232				
231.5 5.2	**SILT**, some sand, trace gravel, brown to grey, very loose to compact, wet		8	SS	3		231				wet spoon
			9	SS	2		230				
			10	SS	26		229				
228.5 8.2	End of Borehole Water level @ 4.9 m (not stabilized)* upon completion. Cave-in @ 5.5 m upon completion.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

GEOTETOB22161AA: Hwy 400/ Tiffin Street

RECORD OF BOREHOLE No BH RW14 1 OF 1 METRIC

GWP 2074-11-00 LOCATION 10+390, 5.1 mLt C/L (N 4914858.3, E288018.2) ORIGINATED BY LG

DIST HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY MP

DATUM Geodetic DATE 09/10/2014 CHECKED BY SH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.8	GROUND SURFACE										
0.0 / 235.5	320 mm **ASPHALT**										
0.3 / 235.0	0.3 m Gravelly Sand **FILL:** Silty Sand, trace gravel brown, compact, moist		1	SS	26						
0.8	**SILTY SAND** trace gravel, trace clay brown, loose to compact, moist		2	SS	9		235				
			3	SS	22		234				5 67 20 8
	dense		4	SS	33		233				
			5	SS	22						
231.3			6	SS	15		232				
4.5	**SILT** some sand, trace gravel brown, very loose, wet		7	SS	1	▼*	231				wet spoon
			8	SS	2		230				
229.4											
6.4	**SILTY SAND TO SAND** trace gravel grey, compact, wet		9	SS	16		229				
			10	SS	21		228				
227.6											
8.2	End of Borehole Water level @ 4.6 m (not stabilized)* upon completion. Cave-in @ 6.1 m upon completion.										

+ ³, × ³: Numbers refer to Sensitivity

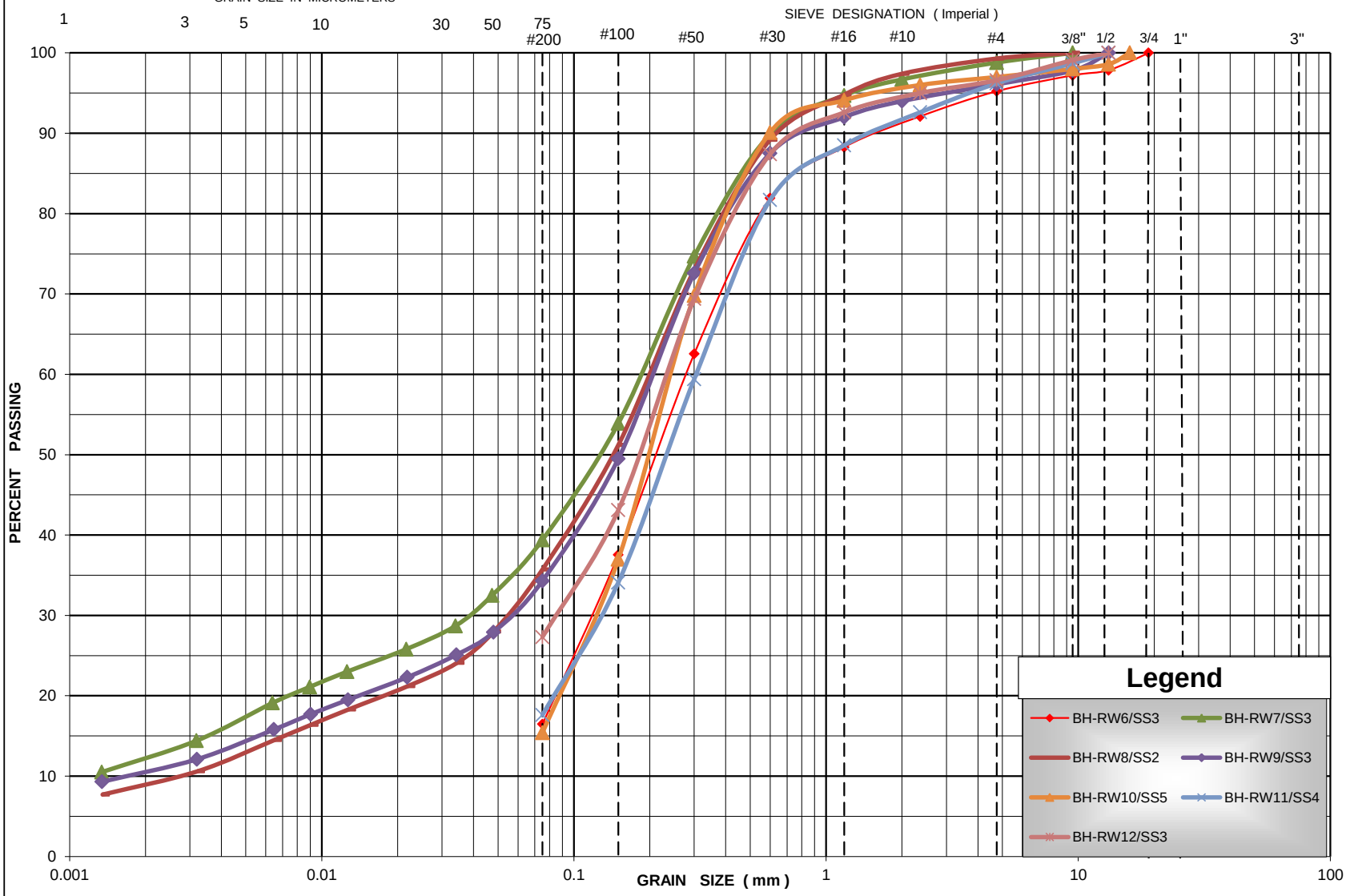
15-20-5 / 10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM LS 702/ ASTM D 422

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



coffey

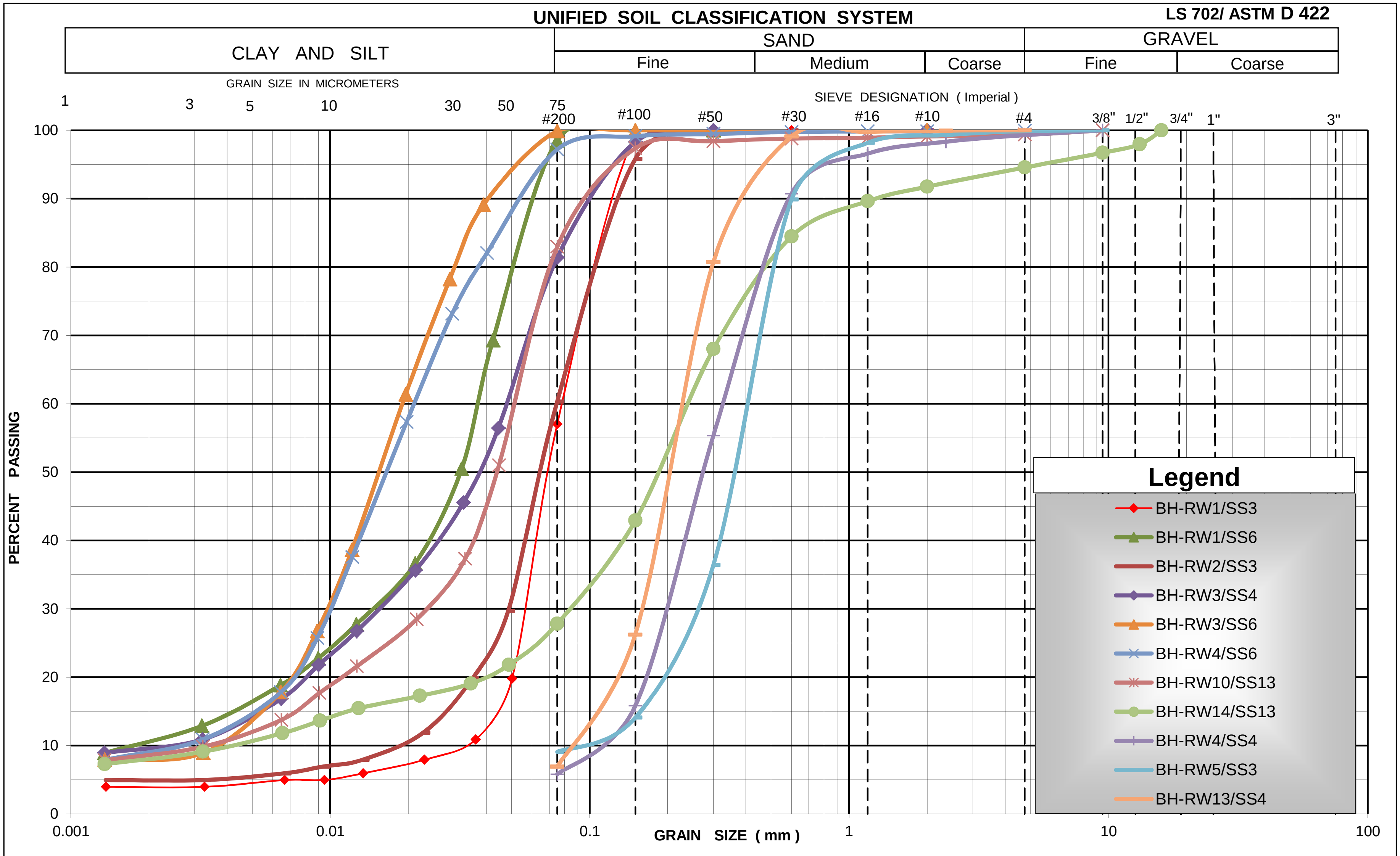
GRAIN SIZE DISTRIBUTION

EMBANKMENT FILL: Silty Sand

FIGURE NO. : B-1

PROJECT NO.: GEOTETOB22161AA

DATE : NOV 13, 2014



coffey

GRAIN SIZE DISTRIBUTION

SANDY SILT TO SILTY SAND, SILT , SAND AND SAND & SILT

FIGURE NO. : B-2

PROJECT NO.: GEOTETOB22161AA

DATE : NOV 12, 2014

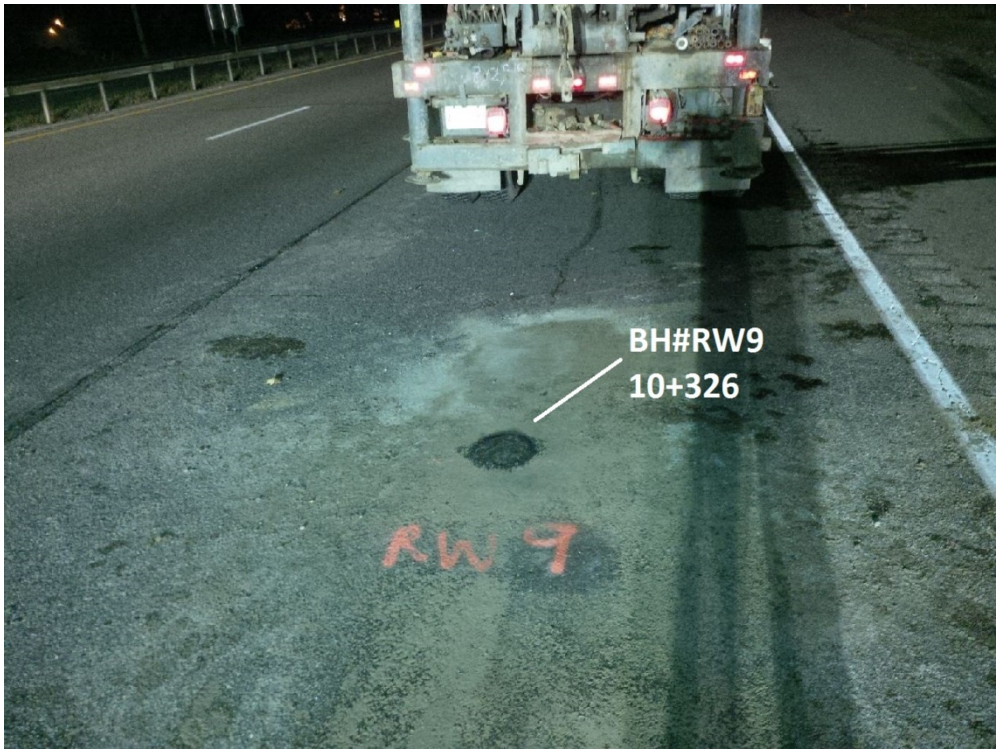
Appendix C

Site Photographs

Photograph 1: Borehole RW4 @ Station 10+062, Looking West

Photograph 2: Borehole RW3 @ Station 29+630, Looking North

Photograph 3: Borehole RW7 @ Station 10+060, Looking North



Photograph 4: Borehole RW9 @ Station 10+326, Looking North

Photograph 5: Borehole RW2 @ Station 29+474, Looking North

Photograph 6: Borehole RW1 @ Station 29+359, Looking South

Photograph 7: Borehole RW13 @ Station 10+267, Looking South

Photograph 8: Borehole RW6 @ Station 29+631, Looking North

coffey

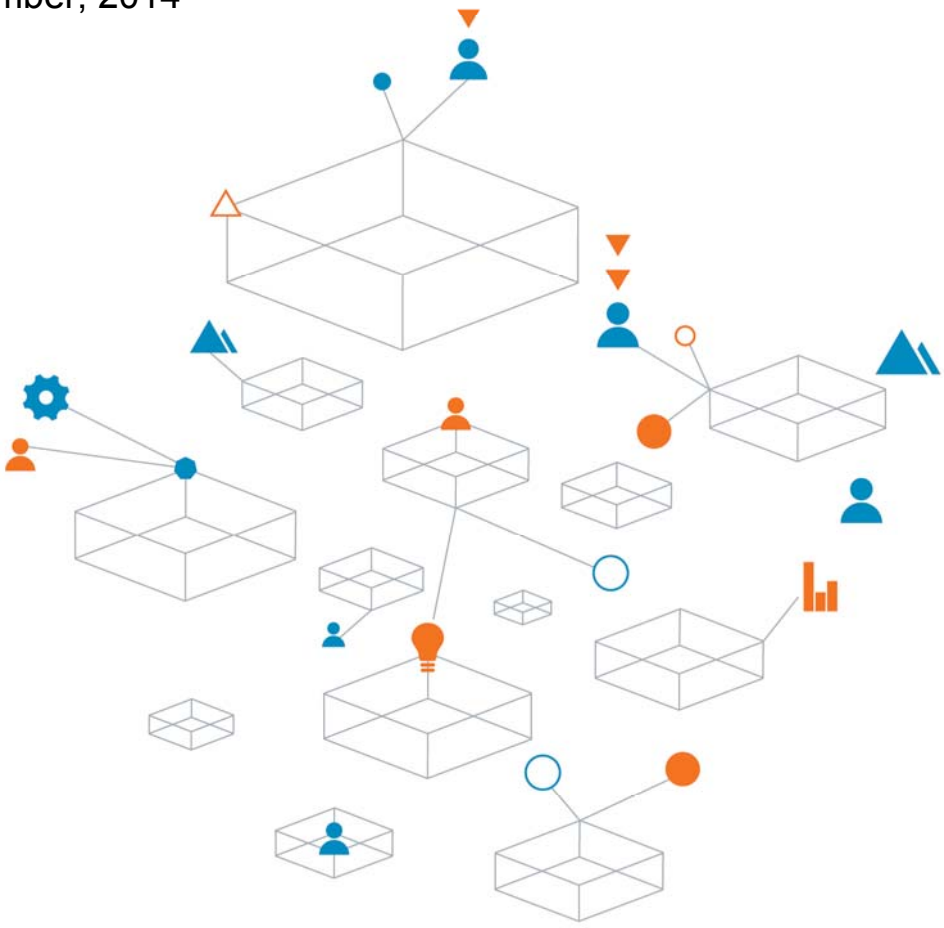
MORRISON HERSHFIELD

Preliminary Foundation Design Report

Highway 400 Retaining Walls and Embankment Widening, from south of BCR to North of Tiffin Street, City of Barrie, G.W.P. 2074-11-00, Design-Build Ready Package

GEOTETOB22161AA - DRAFT

15 December, 2014



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Appendix E: List of Standard Specifications

Appendix F: NSSP

Appendix G: Limitations of Report

5 Discussions and Recommendations

5.1 General

As part of *Highway 400/Tiffin Street Overpass Structure Replacement and Highway 400/Barrie-Collingwood Railway Overhead Structure Rehabilitation*, it is proposed to construct new permanent retaining walls along the eastern right-of-way (ROW) of Highway 400. These walls are needed to widen the Highway 400 platform to accommodate a future 10-12 lane platform. In addition, temporary retaining walls are required to accommodate a revised alignment and a grade raise for improved geometrics and safety. The following is a summary of the proposed retaining wall locations

- Permanent Retaining Walls (NB) - total length 760 m (Station 29+200 to Station 10+300)
- Temporary Retaining Walls (NB) - total length 610 m (Station 29+550 to Station 10+400)
- Temporary Retaining Walls (SB) - total length 610 m (Station 29+550 to Station 10+400)

Fourteen (14) boreholes (RW1 to RW14) were drilled for the design build ready package at or near the locations of these retaining walls. The Highway 400 embankment and the surrounding areas are underlain by loose to compact sandy silt to silty sand, with the groundwater table located 2-3 m below grade outside of the highway embankment area.

5.2 New NB Embankment Construction

A new north bound embankment will be constructed on the east side of the existing Highway 400 embankment, terminating in a vertical retaining wall near the eastern ROW. The proposed highway profile grade raise (maximum 4.5 m) requires the construction of temporary retaining walls within the existing Highway 400 platform. Sectional drawings from MH indicate the proposed wall height will be about 8 m at Station 10+060. The actual embankment height over the existing grade will be about 10 m at that location.

The loose to compact nature of fine sand and silt beneath the new fill and retaining wall requires incremental construction to induce pore water pressure dissipation and ground settlement as the wall height is increased gradually, in order to minimize post-construction residual settlement.

5.2.1 Permanent Retaining Walls

The proposed platform widening will take place on the east side. Property constraints dictate that the 8-10 m high embankment for the widening be contained by a vertical wall face along the eastern extremity. The existing soil and groundwater conditions preclude the use of conventional concrete retaining walls that would need to be supported on a deep foundation. Deep foundations are impractical given environmental concerns with disturbing a TCE (a DNAPL product) plume in this area. An RSS type of wall that can be constructed on a shallow foundation is better suited to the site subsurface conditions. RSS walls are not as settlement sensitive as rigid retaining walls.

Typically, RSS wall facing is supported on a granular bearing pad placed below the frost depth (1.5 m). Given soil conditions somewhat less favourable than those at the Tiffin Street and BCR structure sites, the

soil beneath and at the face of the proposed permanent retaining wall along the east ROW may be assumed to provide a geotechnical resistance at ULS of 300 kPa and an SLS reaction of 200 kPa. The RSS wall design should consider MTO's *"Embankment Settlement Criteria for Design"* issued on July 2010.

Proper abutting between new and existing embankment fill can be achieved by applying *OPSD208.010 Benching of Earth Slopes.*

The anticipated east ROW vertical retaining wall heights are shown in Table 5.2.1.1, along with borehole numbers for reference to the appended log sheets.

Table 5.2.1.1 Wall Height Summary

Borehole No.	Station	Existing Grade (elev., m)	Proposed Highway Grade (elev., m)	Proposed Wall Height (m)
RW1	29+358	233.3	240	3
RW2	29+474	234.0	242	6.5
RW3	29+632	234.5	244	8
RW4	10+060	233.2	243	8
RW5	10+200	234.1	241	4.5

The RSS supplier and wall designer are responsible for internal wall stability. Highway traffic loads should be considered for the wall design, as applicable. The sliding and overturning of the wall should be checked by the RSS wall designer. Global stability analysis can be completed when design drawings are prepared.

Post-construction residual settlement should be anticipated for wall heights greater than 5-6 m. Post-construction settlement will be less if embankment fill loading is incremental and tied to observations of rates of pore water generation and dissipation and ground settlement. The exact magnitude of total and post-construction residual settlement will depend on the rate of embankment filling and the speed of pore water pressure dissipation with time.

5.2.2 Temporary Retaining Walls

The maximum height of temporary retaining walls will be about 4 m. Conventional cast-in-place concrete walls or RSS walls may be selected to retain the proposed grade raise, as these walls will be supported on the existing embankment fill. Table 5.2.2.1 shows anticipated temporary retaining wall heights at borehole locations on Highway 400.

Table 5.2.2.1 Wall Height Summary

Borehole No.	Station	Existing Grade (elev., m)	Proposed Highway Grade (elev., m)	Proposed Wall Height (m)
RW6	29+630	242.3	244	1.5
RW7	10+060	238.8	243	4
RW8	10+200	237.1	241	4
RW9	10+326	236.1	237.5	1.5

5.3 SB Embankment Reconfiguration

The existing SB bound slope will be widened toward the west ROW. A temporary retaining wall will be placed close to the existing highway centreline.

5.3.1 Embankment Widening

The widening towards the west will be made without benefit of retaining walls. Table 5.3.1.1 provides information on the proposed widening in relation to boreholes, for reference to log sheets.

Table 5.3.1.1 Embankment Widening Summary

Borehole No.	Station	Existing Grade (elev., m)	Proposed Widening Width (m)
RW10	29+574	242.9	7
RW11	29+696	241.0	8
RW12	10+120	237.7	12
RW13	10+268	236.7	3
RW14	10+388	235.8	minor

The proposed embankment widening towards the west can be accomplished with 2:1 side slopes. Embankment widening should be carried out in accordance with O*PSS.PROV206 Construction Specification of Grading, OPSS 501 Construction Specification for Compacting*. The existing embankment side slopes should be benched as per Ontario Provincial Standards (*OPSD208.010 Benching of Earth Slopes*).

The soil for the widening of the approach embankments should consist of approved, acceptable earth borrow, free of cobbles and boulders, frozen materials, organic soils, etc. The fill should be placed in loose lift thicknesses not exceeding 200 mm to 300 mm (depending on material type - thicker lift for coarser material). Each lift should be uniformly compacted to at least 95 percent of the material's Standard Proctor Maximum Dry Density (SPMDD). This should be increased to not less than 98 percent of the material's SPMDD within 1 m of the pavement subgrade.

If space is available, mid-height slope benches should be provided as per *OPSD 202.010 slope flattening using surplus excavated material on earth and rock embankment.* Embankment slopes should be protected using sodding or seed and cover (OPSSs 571 and 572).

5.3.2 Temporary Retaining Walls

The recommendations given in Section 5.2.2 also apply to southbound widening temporary retaining walls.

5.4 Construction Considerations

No major dewatering is expected for proposed permanent wall construction and embankment widening. No dewatering will be necessary for temporary retaining wall construction on top of the existing and newly constructed highway embankment.

All excavations, shoring and backfilling should be carried out in conformance with the *Occupational Health and Safety Act (OHSA), Regulation 213/91*, as well as the following specifications.

OPSS 539 – Construction Specification for Temporary Protection Systems

OPSS 902 – Construction Specification for Excavating and Backfilling-Structures.

Excavations will encounter embankment fill and/or natural silty sand and silt. For OHSA purposes, these soils are classified as follows:

Fill	Type 3 above water level
Native Sand-Silt	Type 3 above water level
	Type 4 below water level

Temporary shoring may be required to retain the existing embankment during new construction and to support excavations below or in proximity to existing foundations. Dewatering may not be required for excavations that are kept above about elev. 230-231 m.

Shoring systems should be designed so that the lateral movement of any portion of the roadway protection system will not exceed the established criterion for structural performance levels. In this project, the required Performance Level is 2. Shoring systems should be designed by Professional Engineers specializing in shoring works. The soil parameters for shoring design are given in Table 5.4.1. The shoring design should satisfy the requirements of *OPSS539*.

Table 5.4.1 Recommended Unfactored Parameters for Temporary Shoring Design

Soil Type	K_a	K_o	K_p	Unit weight γ (kN/m^3)
Embankment Fill	0.36	0.53	2.77	19.5
Native Granular Soils	0.36	0.53	2.77	19.5

It should be pointed out that cobbles and random boulders may be present within the existing Highway 400 embankment fill. Where present, they may cause some problems during the installation of shoring elements, such as vibrated or driven interlocking steel sheet piles.

5.5 Slope Stability

The soil below the existing and future embankment is essentially fine-grained non-cohesive. The existing Highway 400 embankment, which stands 7 m above ground surface within the project limits, is stable with 2:1 side slopes. New embankment of similar heights and side slopes should therefore also be stable against deep seated types of slope failure.

Slope instability may occur for excavated slopes steeper than permitted by OHSA soil type requirements when constructed without benefit of shoring, or when surcharged unintentionally or on purpose. Such instability is of the utmost concern when excavations occur close to existing foundation elements.

As mentioned earlier in Section 5.2.1, the vertical wall heights of up to 10 m will need to be assessed for safety against global instability. This can be done when the RSS wall design is known (i.e., reinforcing type and vertical and horizontal spacing, type of backfill soil, etc.). The reinforcing elements in RSS walls provide shearing resistance in addition to that provided by the compacted backfill.

5.6 Seismic Considerations

The following seismic design parameters are relevant (CHBDC S6-06 Sections 4 and 7):

- Zonal acceleration ratio: 0.05
- Site Coefficient: 1.2

The embankment fill and natural soil beneath and adjacent within the anticipated work zone and embankment widening are considered low risk potential for liquefaction.

5.7 Frost Depth

The design frost protection depth is 1.5 m.

5.8 Instrumentation and Monitoring

The stratified nature of the fine sand and silt deposits beneath proposed new embankments and lack of information of soil conditions below elevation 225 m require, for purposes of due diligence, that a program of instrumentation and observational monitoring be implemented to check on the rate and degree of pore water pressure development under loading and rates of dissipation that could be used to permit the application of additional loads without compromising the safety of the fills during construction..

6 Scope of Work Required for Detailed Design

Due to environmental constraints and the DB nature of the project, this investigation falls short of MTO requirements for both lateral coverage of boreholes and depth of borings for the proposed earthworks and structures. It may become necessary to drill additional and deeper boreholes to comply with *RFP, Appendix 6.8, Minimum Requirements for Foundations Engineering Applications,* unless waived by the MTO.

7 Closure

The "Limitations of Report" as presented in **Appendix G** are integral part of the report.

For and on behalf of Coffey.

Draft

Gwangha Roh, P.Eng., Ph.D.
Associate Geotechnical Engineer

Draft

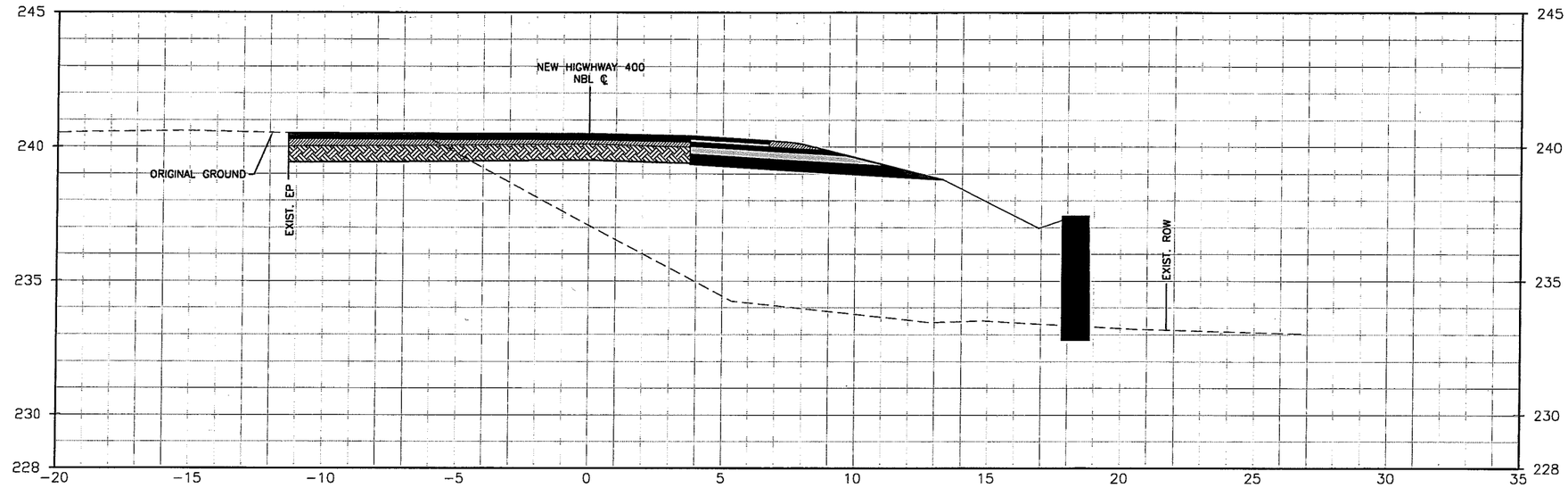
Sanket Shah, P.Eng.
Project Manager, Geotechnical Engineer

Draft

Cam Mirza, P.Eng.
MTO Designated Contact, Principal

Appendix D

Cross-sectional Drawings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240
235
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NEW HIGWHWAY 400
NBL ℄
ORIGINAL GROUND
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0
5
10
15
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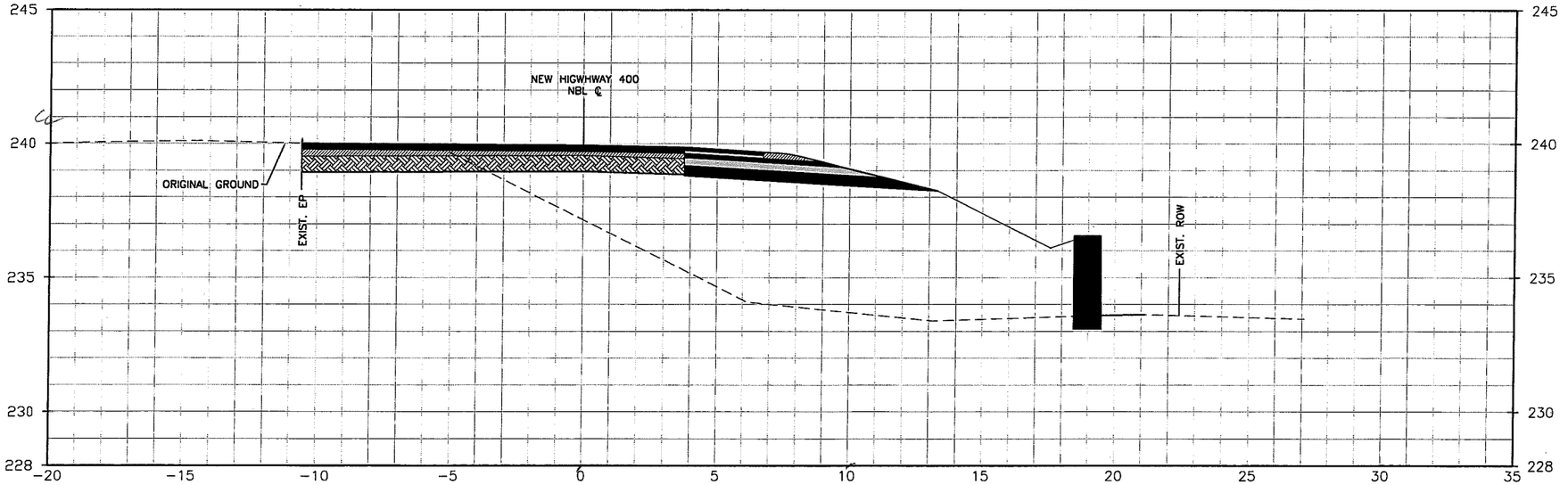
25
30
35

29+375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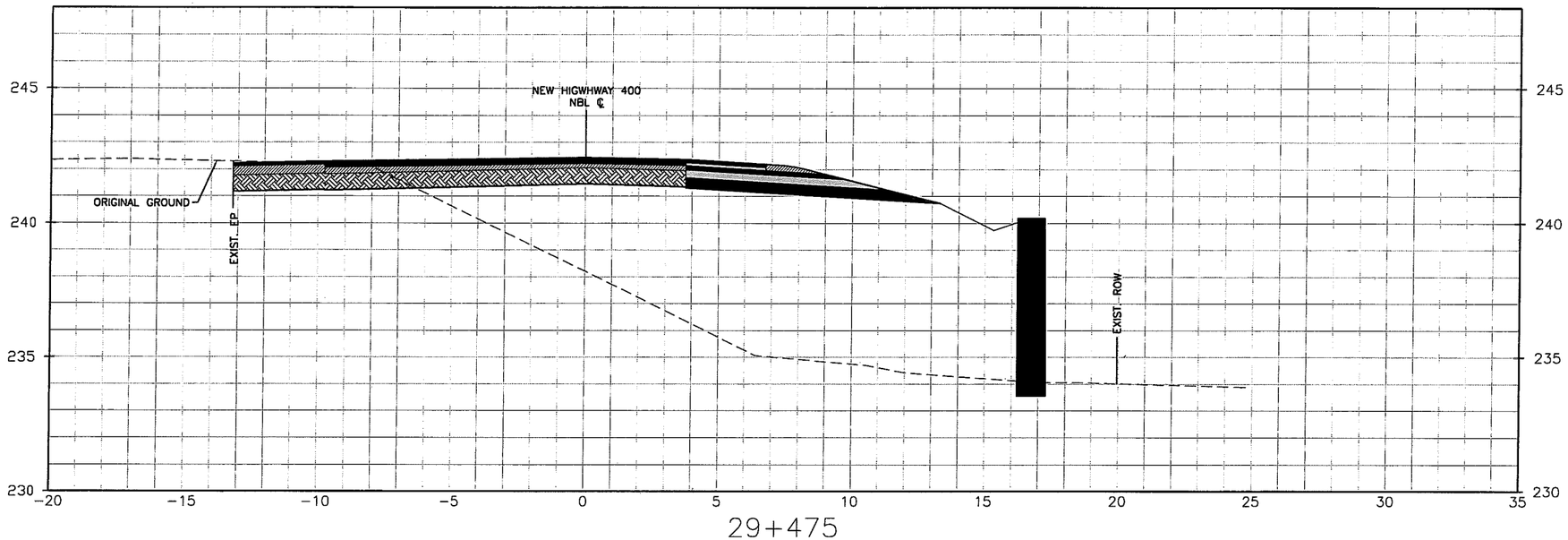
30
35

29+350



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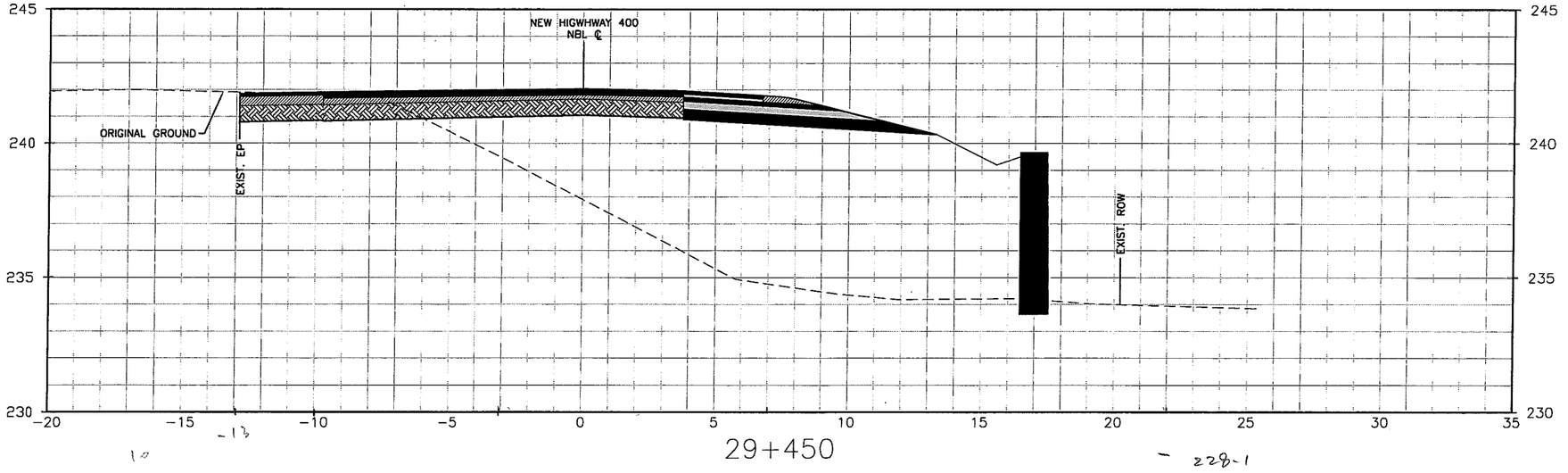

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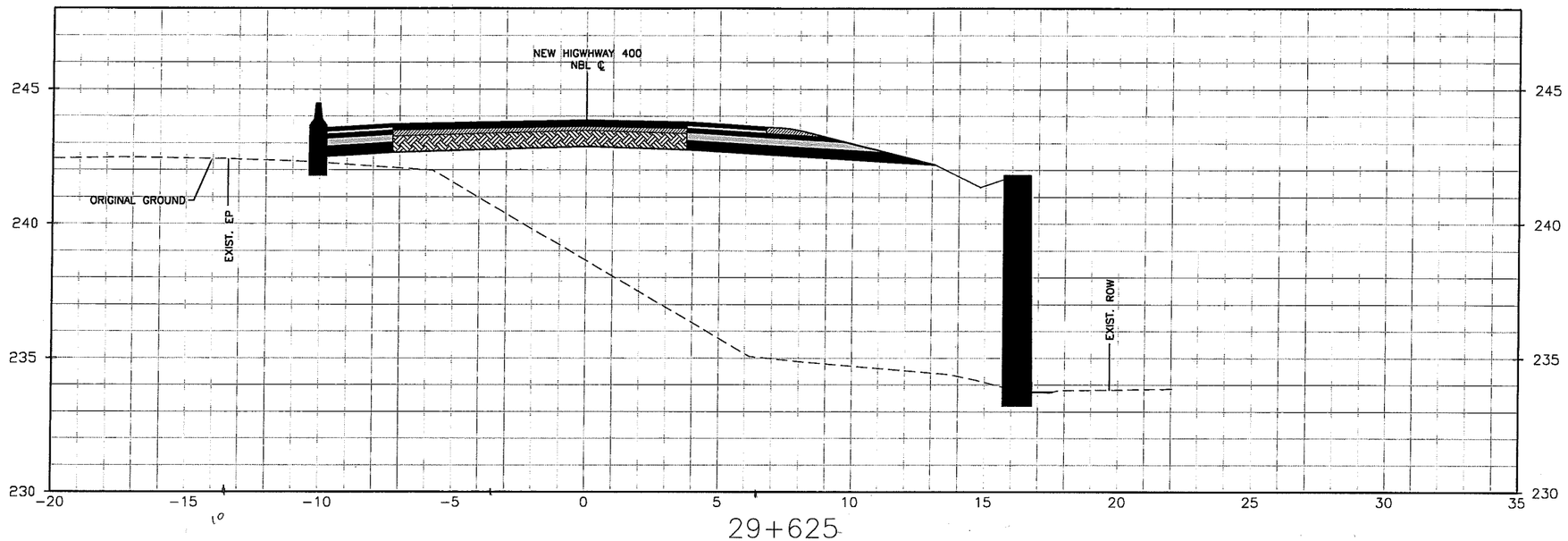

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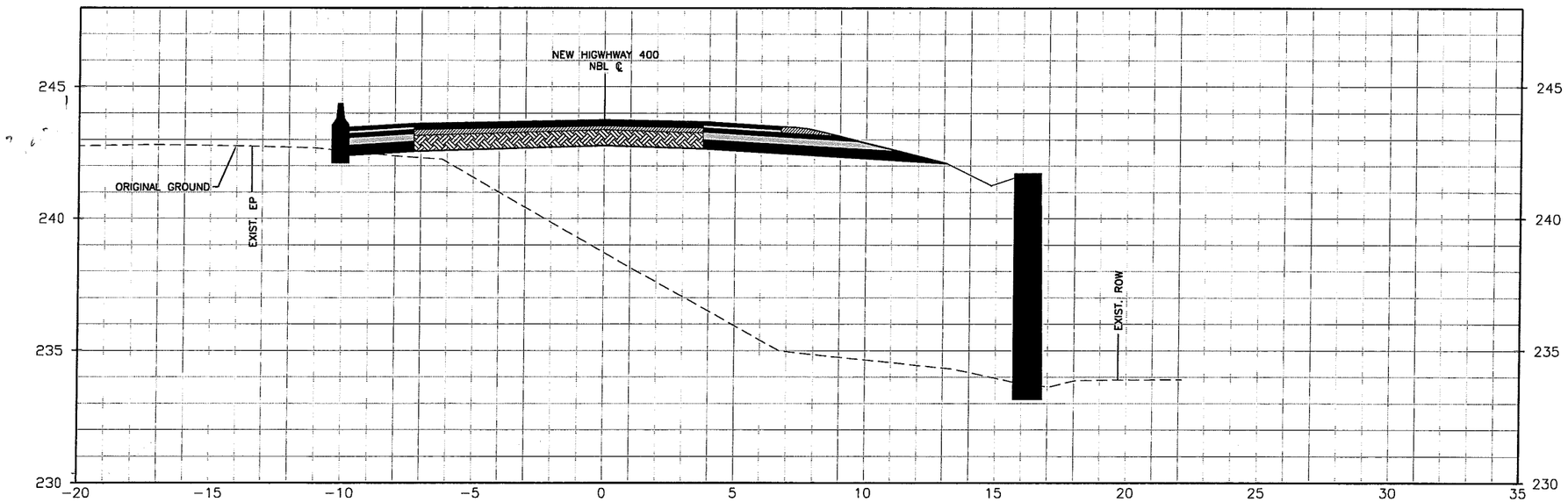

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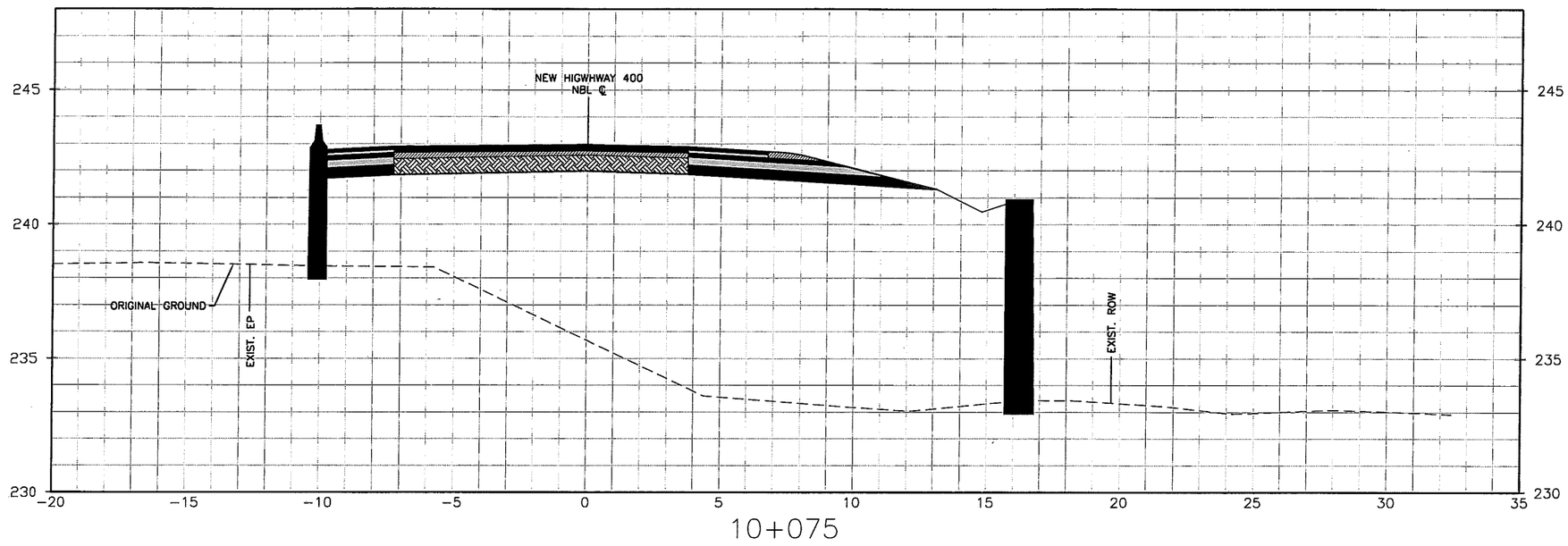
18.12.2009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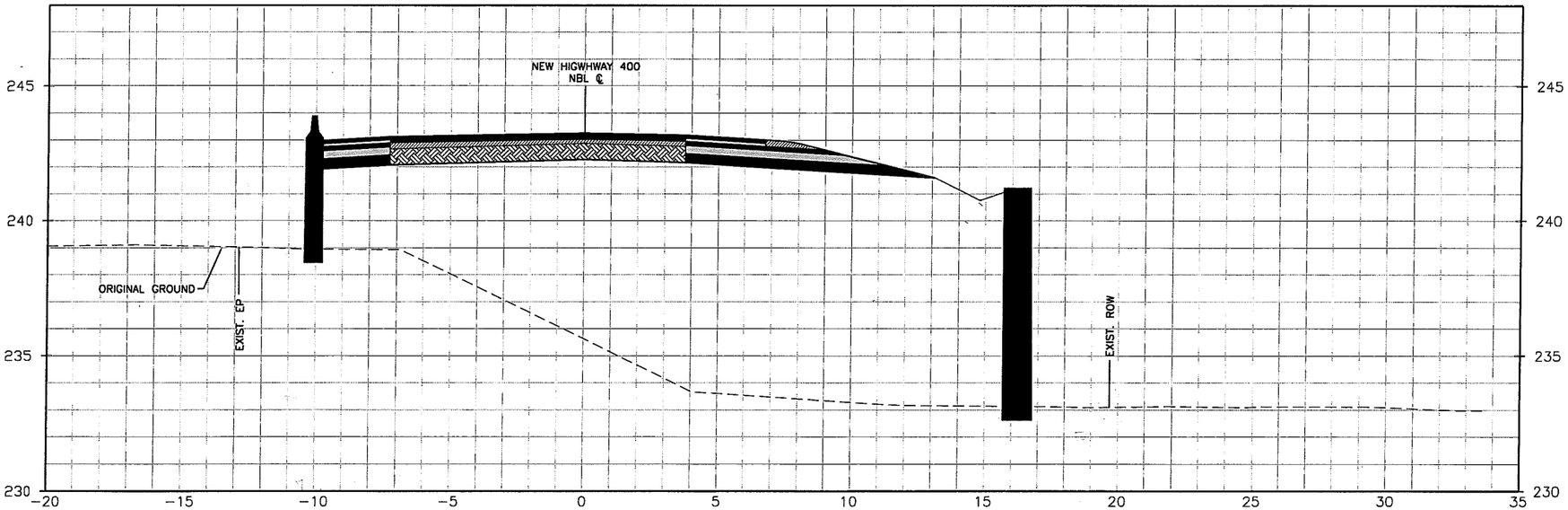
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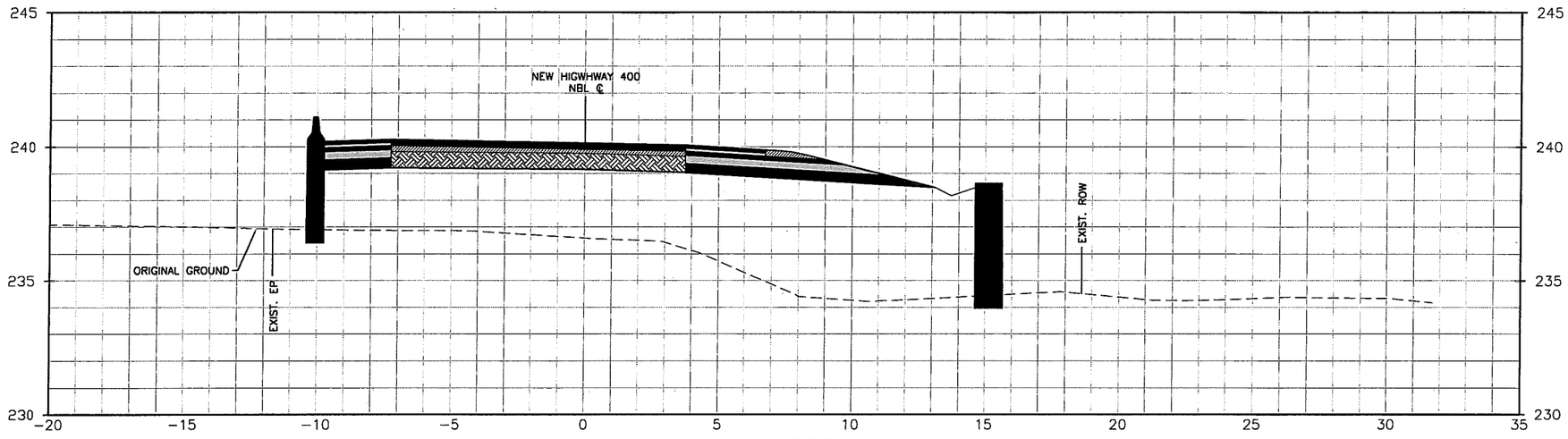
10+050



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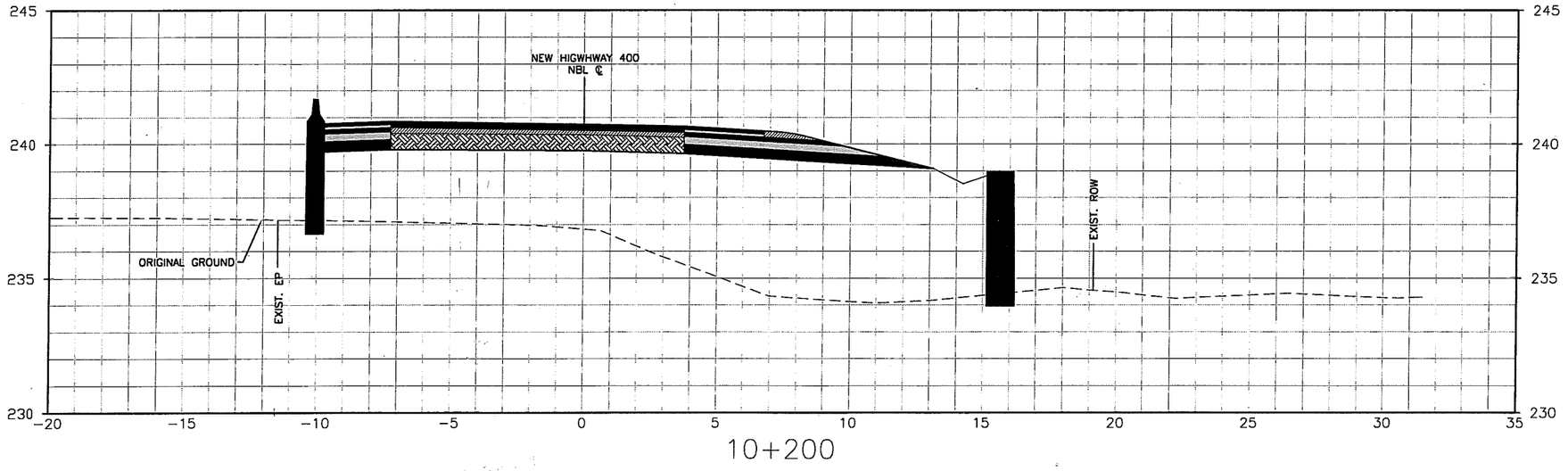

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NBL STAGE 1 PRELIMINART SECTIONS.dwg

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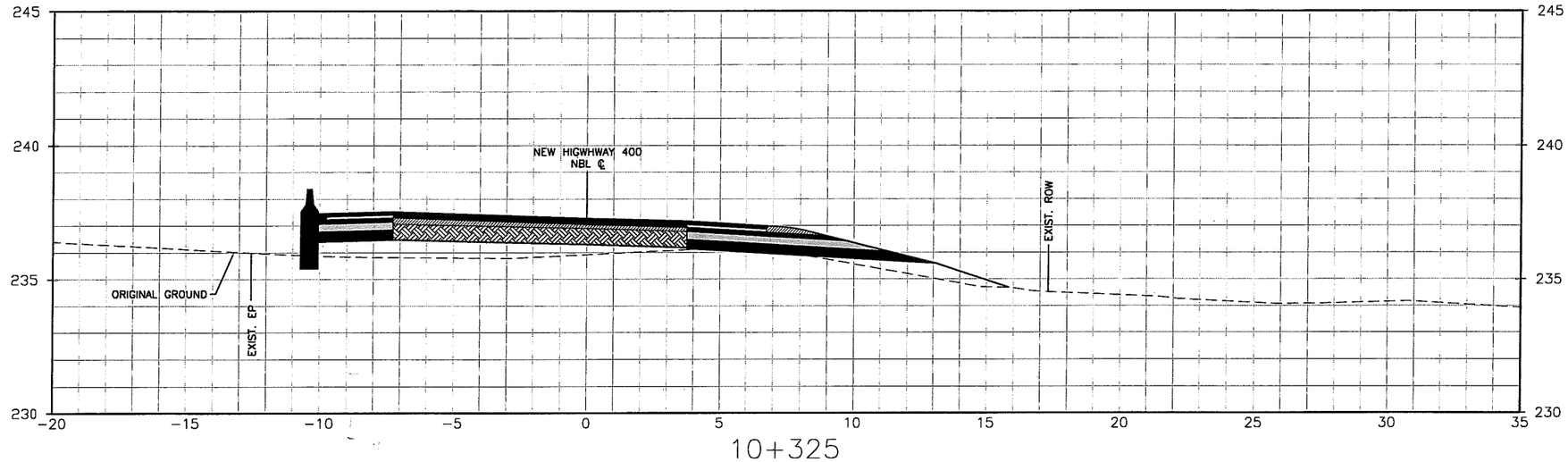

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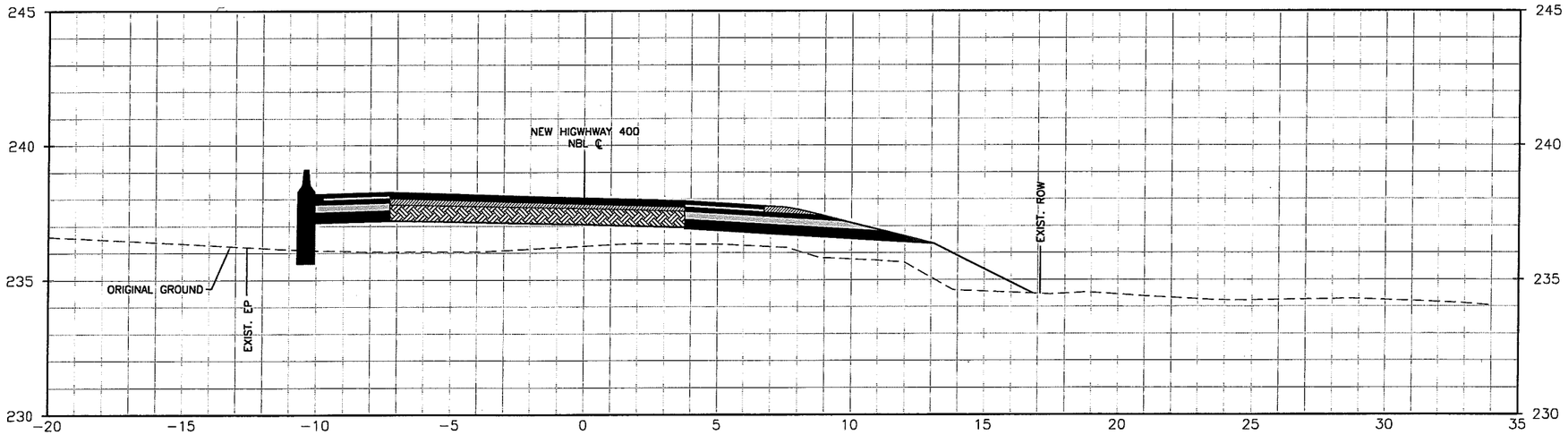

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NBL STAGE 1 PRELIMINART SECTIONS.dwg

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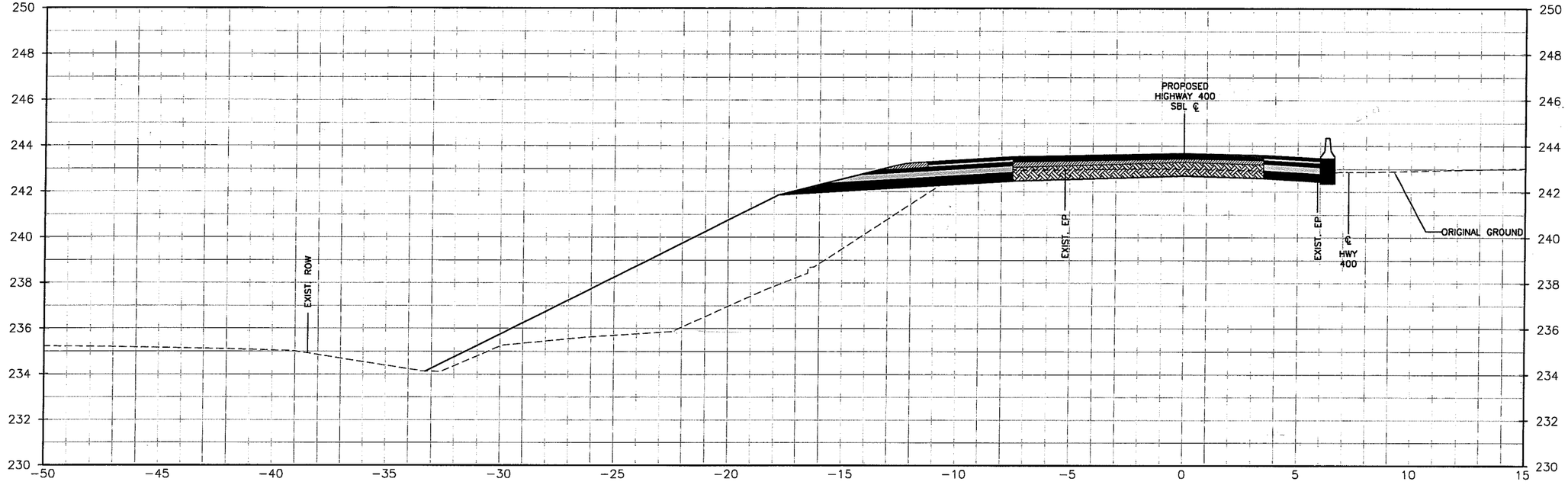

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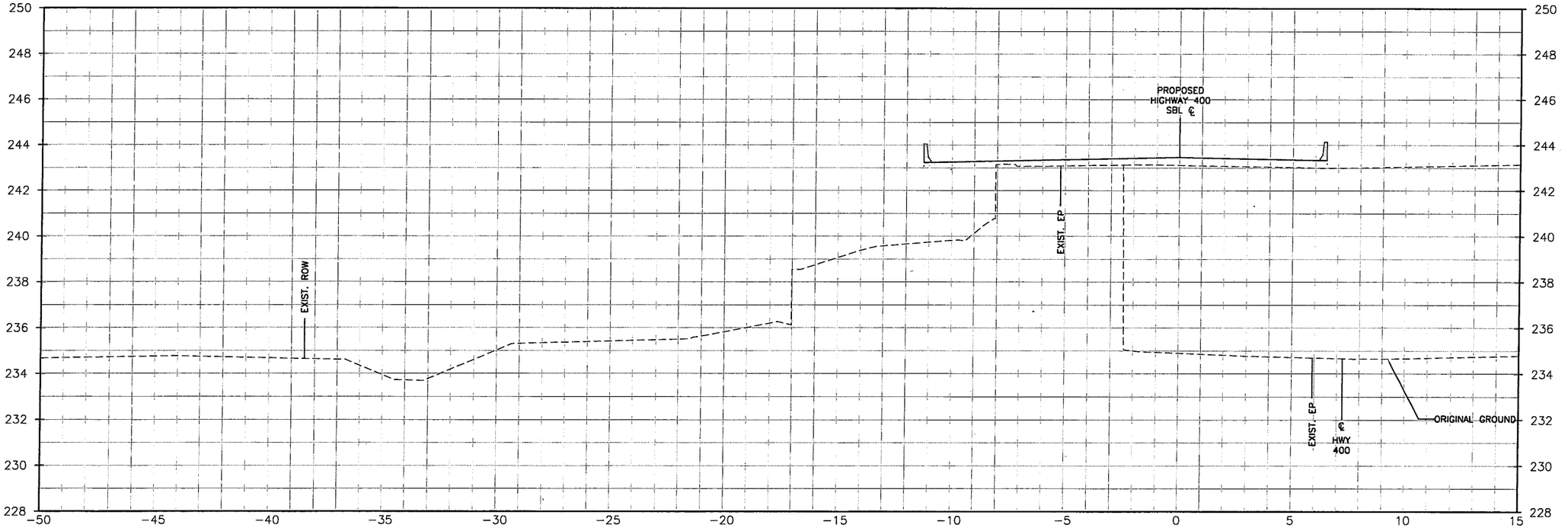

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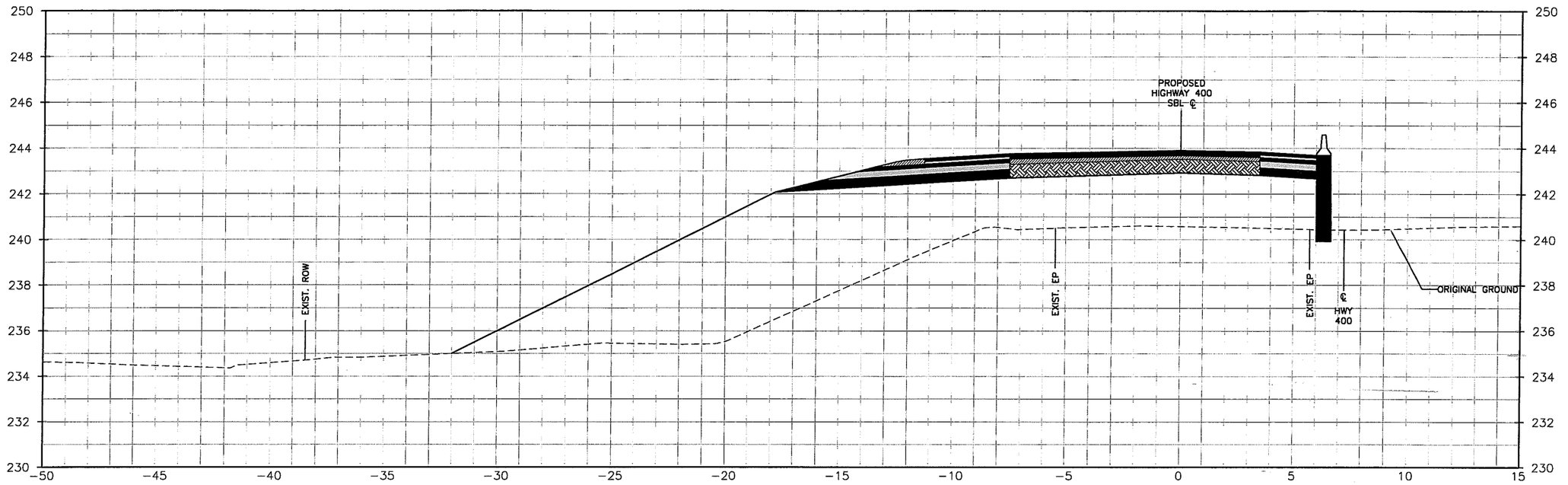

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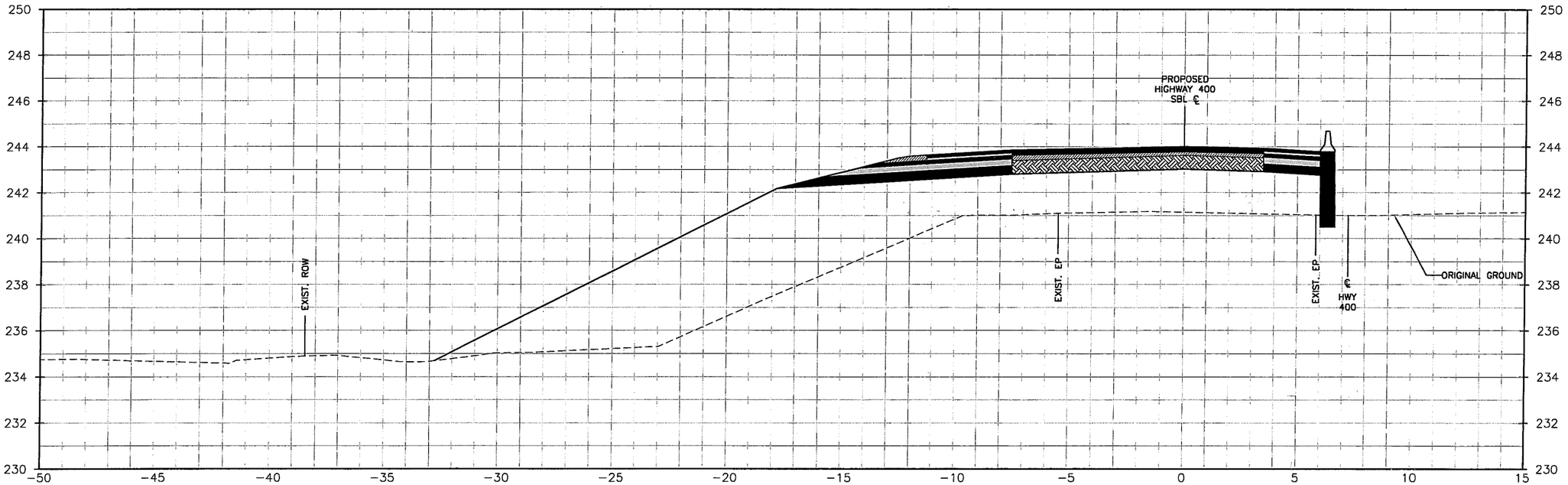

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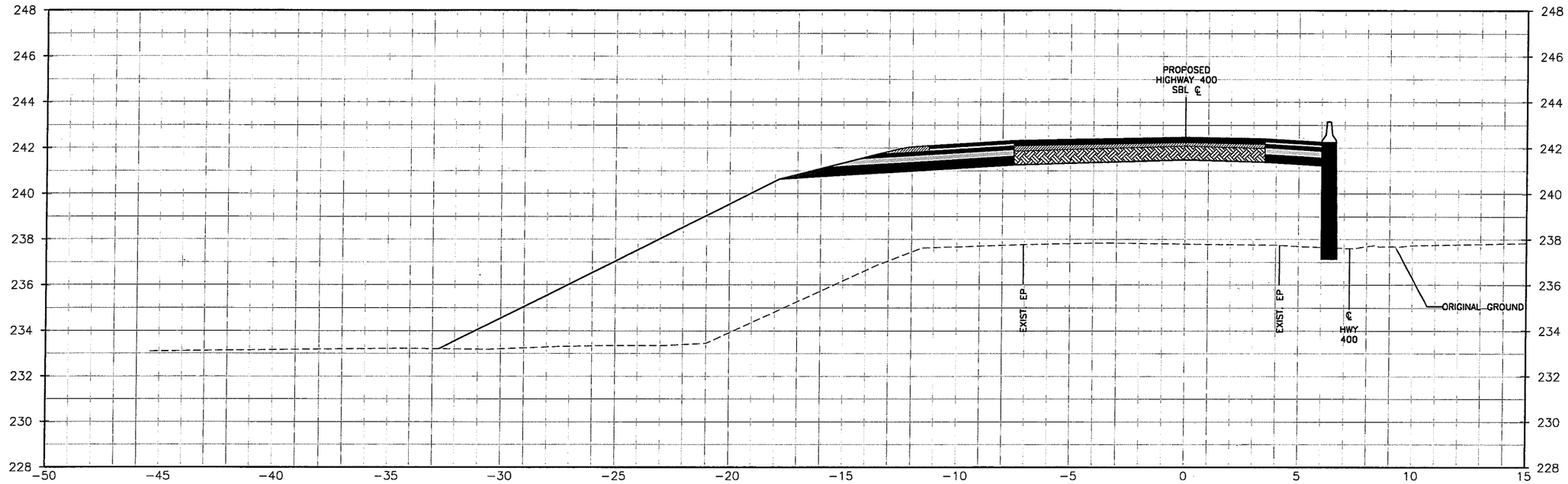

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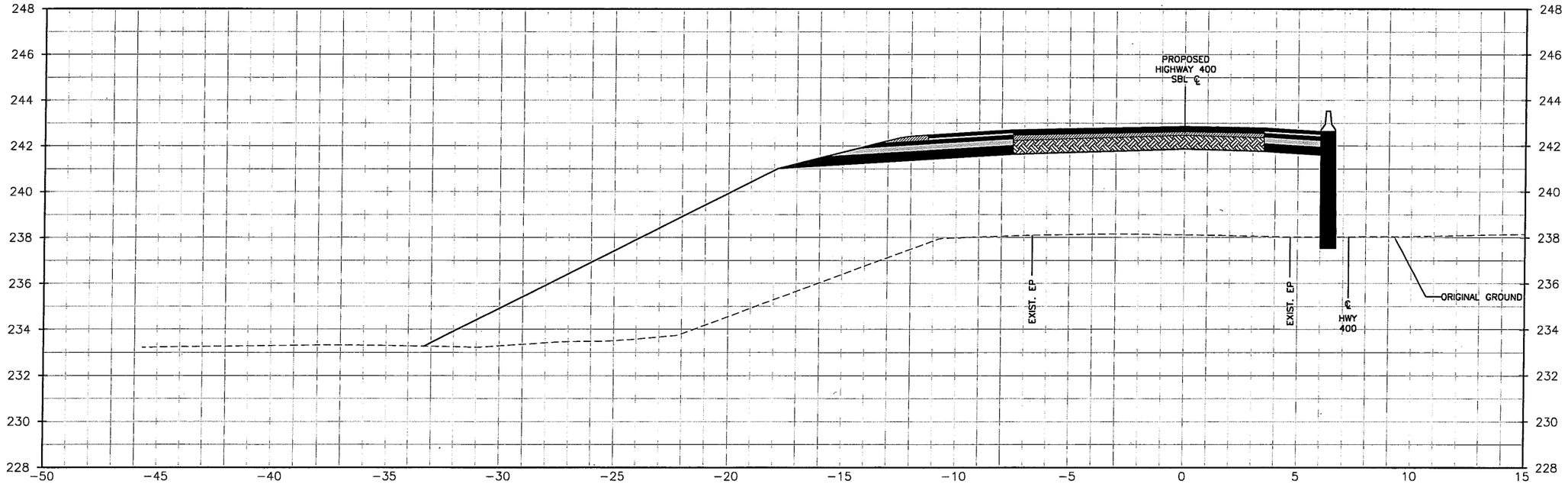

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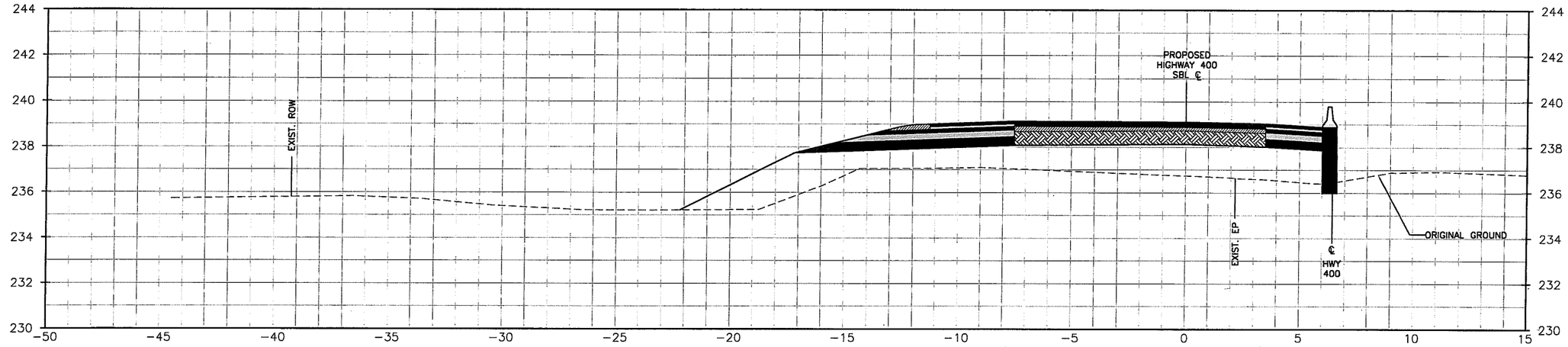

B.S

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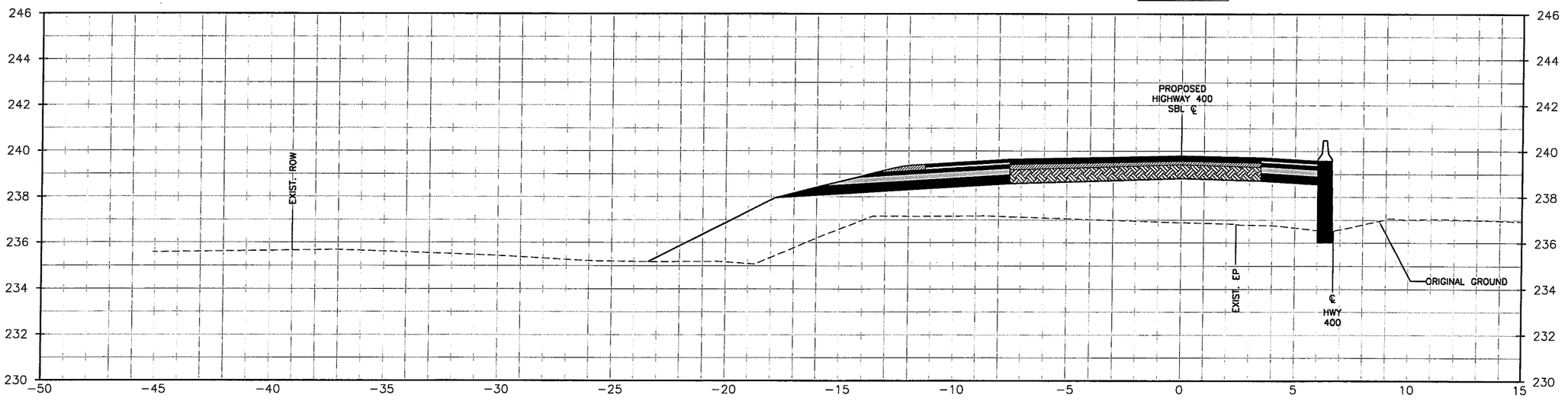

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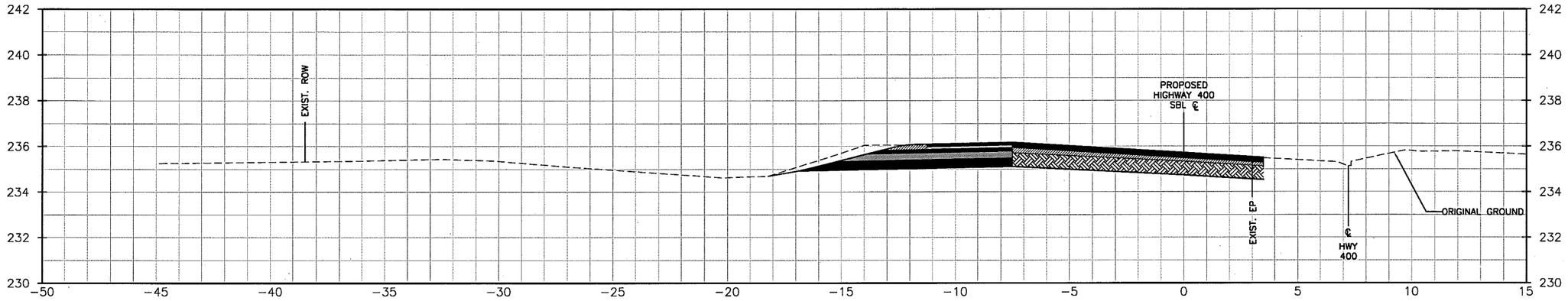

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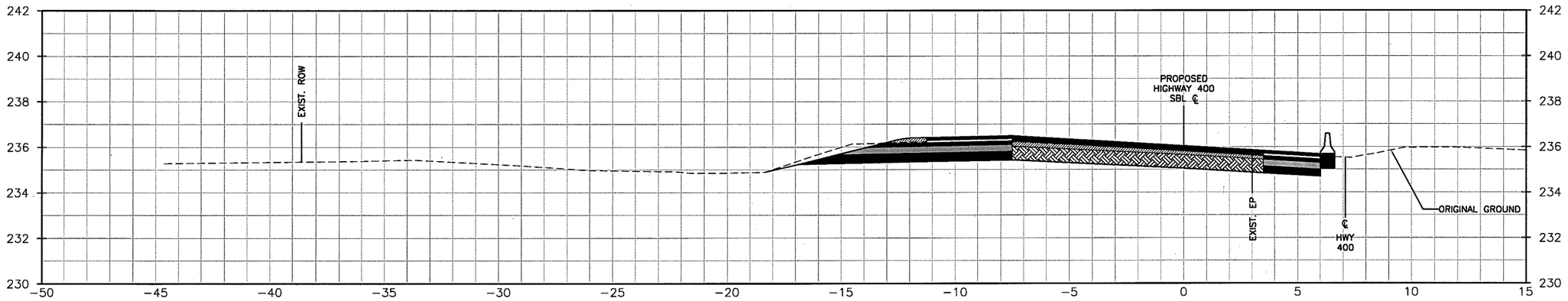

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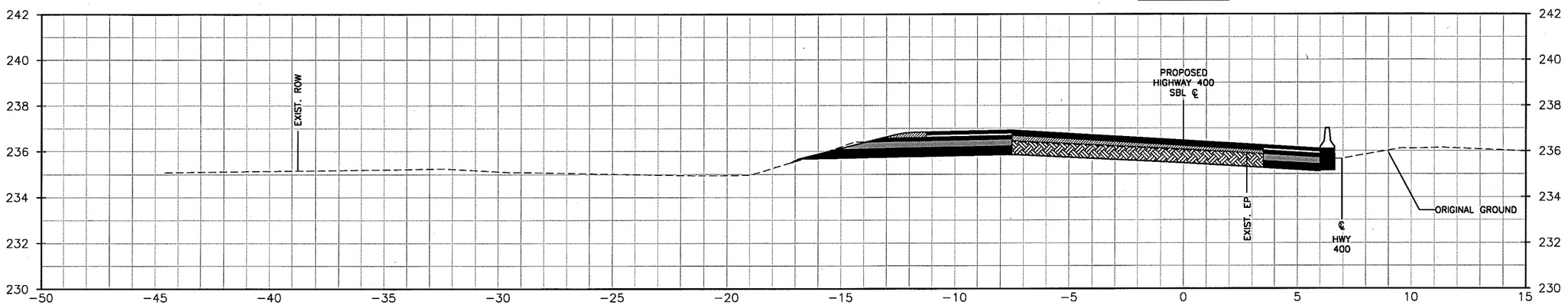

Appendix E

List of Standard Specifications

OPSSs

OPSS.PROV206 Construction Specification of Grading

OPSS 501 Construction Specification for Compacting

OPSS 571 Construction Specification for Sodding

OPSS 572 Construction Specification for Seed and Cover

OPSS 539 – Construction Specification for Temporary Protection Systems

OPSS 902 – Construction Specification for Excavating and Backfilling-Structures.

OPSS 915 - Construction Specification for Sign Support Structures

OPSDs

OPSD 202.010 slope flattening using surplus excavated material on earth and rock embankment

OPSD208.010 Benching of Earth Slopes

Appendix F

NSSP

Vibration Monitoring

Special Provision

The vibration monitoring equipment shall be placed on the existing structure such that it will not be disturbed. The location should be as close as possible to the piling works.

The vibrations at the existing structure shall not exceed 100 mm/s (peak particle velocity).

The Contractor shall take readings on the first pile in each pile group (i.e. at each corner of the abutment), starting with the pile furthest away from the existing structure. As a minimum, the readings should be taken and recorded during the first 3 m of driving and during seating of the pile onto the bedrock.

The results shall be certified by the Quality Verification Engineer as being accurate and meeting the requirements of the specification. The results shall be submitted to the Contract Administrator prior to continuing with the remaining piles. As a minimum, the pile number, location, set criteria and driving log must be submitted with vibration monitoring results.

If the results are acceptable, the Contractor may continue with the remaining piles with readings taken during driving of each pile. Subsequent vibration readings should be taken for each pile during bedrock seating. The results of the subsequent piles should be certified by the Quality Verification Engineer as being accurate and meeting the requirements of the specifications. The results shall be submitted to the Contract Administrator at the end of each day.

If the readings are not within the limits stated above, the Contractor must alter his driving procedures until the vibrations on the existing structure are within acceptable levels. The above process must be repeated for each pile.

Appendix G

Limitations of Report

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Coffey at the time of preparation. Unless otherwise agreed in writing by Coffey it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of test holes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Coffey accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time. Any user of this report specifically denies any right to claims against the Consultant, Sub-Consultants, their officers, agents and employees in excess of the fee paid for professional services.